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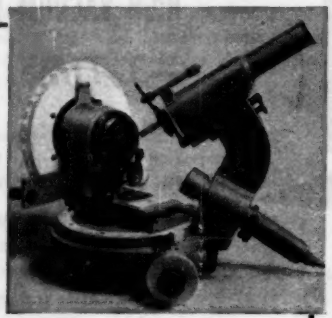

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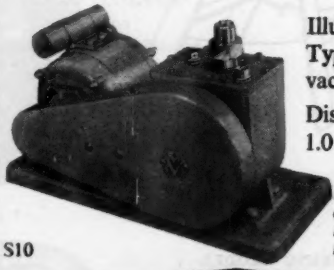

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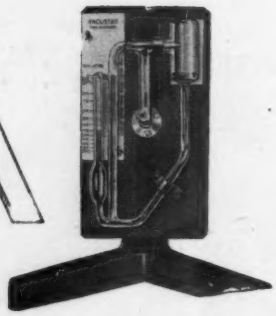

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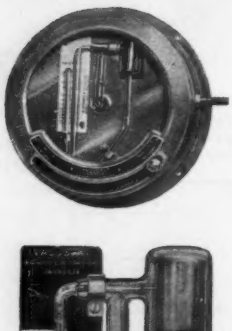

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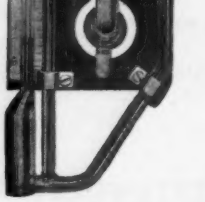

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NATURE

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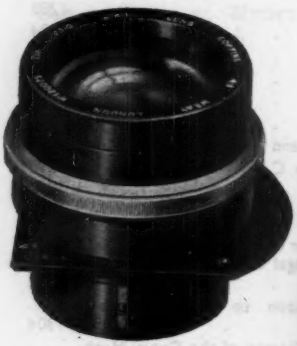

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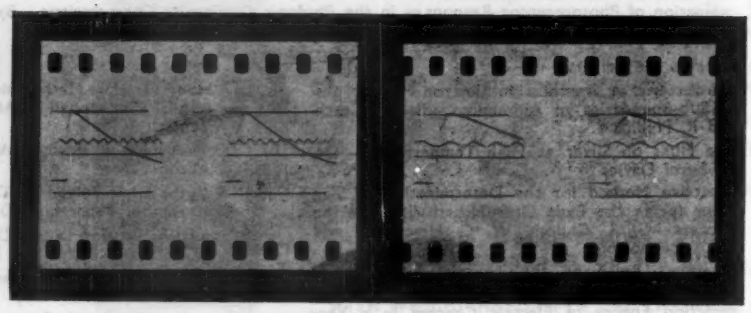

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UNIVERSITY EXPANSION IN BRITAIN

SIR JAMES MOUNTFORD, vice-chancellor of the University of Liverpool, has examined the problems with which universities in the United Kingdom will be confronted in the next ten years in a recent series of three articles in the *Manchester Guardian*. Foremost is the difficulty of providing enough places to meet the demands for scientists and technologists. Numerical expansion is, of course, no new problem to the universities, and Sir James rightly pays tribute to the magnificent performance of the universities since the end of the Second World War. In 1938–39 there were 50,250 students; by 1949–50 this figure had risen to 85,400, mainly because of the influx of ex-Service men. It was assumed that this remarkable achievement was but a temporary operation and that numbers would settle at about 70,000. In 1946, however, the Barlow Committee had wisely assessed the country's needs and had called for a considerable increase in science and technology graduates, together with a substantial expansion in students of humanities. The universities' response to the challenge is well known; their numbers have now risen to 88,700.

To rest content with these numbers, however, would quickly lead to national disaster, and they are already seen to be pitifully inadequate. This was brought out by Lord Pakenham in the debate in the House of Lords on May 22 when, with proper concern for providing the country with a sufficient supply of scientists and technologists but less with the practical means of finding and training them, he suggested that we should not rest content with any target ten years from now less than 176,000 students—double the present total. Lord Pakenham's figures would be difficult to achieve and most observers will at least be content for the time being if a permanent increase to about 120,000 is achieved by 1965; this is the figure currently being discussed by the University Grants Committee and the universities.

Where are these men and women to come from? They will come, as Sir James Mountford explains, from the 'bulge' and the 'trend'. The 'bulge' is the result of the increased birth-rate since 1942. For every 100 boys and girls aged eighteen in 1957, there will be 112 in 1961, 144 in 1965, and still 112 in 1971. What has come to be called the 'trend' is the number of extra students who are staying on into the sixth forms and qualifying for university entrance; over the past four years, there has been an annual increase of 5 per cent in the number of pupils taking general certificates of education at advanced level. The cumulative effects of the 'bulge' and the 'trend' will mean that, even when the peak figures of 1965 have been surmounted, the subsequent 'plateau' will be appreciably higher than the present university population.

This challenge to the universities of Britain not only raises problems of finance and buildings, but also many fundamental principles; chief among these is the optimum size of a university. This will vary from place to place; but, as Sir James puts it, "when that number has been exceeded, a university falls asunder into a congeries of ill-related departments, the institution is no longer a fellowship of learning but an intellectual emporium dispensing parcels of information". This is a weighty matter which is never far from the minds of those who are concerned with the universities' well-being. Yet expansion there must be, and fears must be used as warnings rather than as bases for inaction.

Some universities, undoubtedly, have grown to sizes which may, even now, be inimical to their proper functioning. Oxford has 2,700 and Cambridge 2,360 more students than in 1938–39; to retain their traditional and invaluable patterns would necessitate the building of new colleges—at enormous cost. London has a student population of 19,400, and it is difficult to believe that much greater numbers would be desirable or beneficial. For many years in Wales and Scotland a much greater proportion of the population than in England has benefited from university education; it is doubtful whether considerable expansion in the near future seems desirable. Immediate expansion would seem to lie with other universities, where the number of students now falls between 1,500 and 4,000.

Recommendations to individual universities have already been made by the University Grants Committee, and these should soon become publicly known. Since the present proposals for expansion go much farther than the Barlow Report in providing for increased numbers of graduates in science and technology, it is inevitable that much of the expansion will take place in centres where there are already adequate facilities for teaching technologies and where there is a considerable industrial hinterland to support the university. Even if such Universities as Southampton, Exeter, Reading and Hull and the University College of North Staffordshire increase to double their size, the main expansion to provide places for many more students is likely to take place in the Universities of Manchester, Durham, Leeds, Birmingham, Sheffield, Liverpool, Bristol, Nottingham and the Colleges of Technology in Manchester and Glasgow.

Yet, assuming expansion on this scale at all the universities and even more at some, the number of places available would still fall short of the University Grants Committee's anticipated target by several thousands. It is surprising that Sir James has not pressed the case for one or more new universities. The case for a University of Sussex at Brighton has been persuasively argued, while York also has its supporters; advocates for establishing universities in the new towns are also making themselves heard. Such a development may be the only answer to short- and long-term needs if the spirit of existing universities is not to be destroyed by over-loading. The creation of a 'new town' university would have the merit of integrating town- and country-planning

in preventing excessive growth of existing conurbations and making effective use of land.

Another question raised by rapid university expansion is that of balance. Of the 40,000 places to be provided in the next ten years, about two-thirds will be in faculties of science and technology. Whereas in 1938–39 students of science and technology accounted for 25·9 per cent of the university population, by 1965 the proportion will have grown to 62 per cent. This should, as Sir James wisely points out, present no cause for alarm and despondency. In numbers, arts students will still be as many as the number of science and technology students in 1956. They, and their teachers, should accept their new responsibility "of helping a society which cannot avoid becoming technological to get its human and moral values right".

Rapid expansion is also bound to cause concern about the quality of students and degree standards. For those extra students whose existence is due to the increased birth-rate there need be little anxiety if we take for granted that the proportion of children with high intelligence will remain approximately constant. Anxiety is greater about the intellectual levels of those young people whose university entrance has been governed by the 'trend'. Fortunately, an inquiry undertaken by a committee of vice-chancellors—the report of which has only just been published—shows that there is still a pool of qualified students who will do well at the universities. In his address to Convocation on June 30, 1956, Sir Charles Morris, vice-chancellor of the University of Leeds, paid warm tribute to the work of the student population and the standards obtained by them in the past academic session. Sir James Mountford believes that "the crucial problem will not be the supply of students, but the provision of funds to enable them to come to the universities". When he talks, however, about there being no lack of students of the right quality "if the loss of good material from the grammar schools between the ages of 16 to 18 continues to be checked", some doubt arises about his awareness of what happens to many of the boys —and some girls—in this age-group.

The report of the Central Advisory Council for Education, which investigated this point on behalf of the Ministry of Education, might well have been written differently if the Council had contained more members with industrial experience in companies with extensive education and training schemes*. They could have shown how many of these so-called 'losses' to higher education have, in fact, become technologists by taking degrees at universities after one or two years experience in industry. There is a growing number of leading industrialists who believe that men educated in this way have more to offer to industry than boys who go to university direct from school.

Few graduates will quarrel with Sir James Mountford's belief that we should give serious attention to the quality of university teaching; it was no cynic who remarked that as one climbed the education ladder the lower became the level of pedagogy. The traditional university lecture has been well described as a means of passing notes from the lecturer to the student without the transmission of thought. The suggestion put forward by the Willis Jackson committee for the establishment of a staff college whereby lecturers in senior technical colleges could meet to discuss teaching methods would bring even greater results if it were first adopted by the universities. Few university teachers would fail to profit from reading some sound advice on teaching technique recently published by G. Kitson Clarke called "The Art of Lecturing"*.

The difficulty of providing enough of the right kind of university staff to meet the increased number of students needs no underlining. These teachers must be recruited in advance of the expansion; the dilemma is that the universities must have the teachers before they can take the students from whom the enhanced supply may be expected. An imaginative recruiting campaign will be needed to find the 4–5,000 additional teachers required, and this should find support from the more attractive salaries which are to come into operation on August 1 of this year.

The provision of academic accommodation and student residence will be no less difficult than finding an adequate number of teachers. Although money has been available, the difficulty of providing raw materials and of building quickly enough has meant that, by 1957, the new accommodation provided has been barely one-third of what was regarded as necessary even by the Barlow Report. A great deal more money is being provided by the Government but, with stringent regard for building economies, means of spending it must be greatly speeded up; where to build and how to build have led to the appointment of experts at the universities to advise on patterns of development. Patterns of development are not enough, however, and they can be made nugatory in large cities by local authorities with pressing rehousing problems.

The difficulty of providing sufficient academic building is aggravated by the necessity for student residences. Halls of residence are now accepted as essential elements in the framework of higher education. Without including Oxford and Cambridge, about 7,500 additional places in such halls will be required by 1965 to maintain the present inadequate figure of 22·5 per cent of students resident in halls. This assumes that other students will be able to find lodgings; but, as wardens of university lodgings are frequently pointing out, the number of lodgings available may already have reached its peak and, as standards of living continue to improve, may even decline. The report of the sub-committee appointed by the University Grants Committee to "consider the role which should be played by halls of residence in the education of university students and its relationship to other forms of student organization" will receive a warm reception if it contains novel proposals for the housing of students. Sug-

* "Early Leaving." A Report of the Central Advisory Council for Education. (London: H.M.S.O., 1954.)

* "The Art of Lecturing." By G. Kitson Clarke. Pp. 11+20. (Cambridge: Heffer and Sons, 1957.) 1s. 6d. net.

gestions that students might be economically housed in blocks of houses resembling council houses should be carefully considered on their merits. Are university planning authorities familiar with the 'student villages' at Oslo and Upsala? Such an approach may be the only answer to what is admittedly a difficult problem.

The spirit and standards adopted by the Ministry of Education and local education authorities to meet successive crises in primary and secondary schools since the Second World War may point the way whereby the universities can deal with their expansion problems. For in considering their own needs they should never forget the needs of the country as a whole. When inviting industrial organizations to contribute vast sums of money to provide adequate facilities for much-needed scientists and technologists, university authorities would do well to remember that much of that money comes from many firms where facilities for training school recruits are inadequate by any respectable standards.

Sir James Mountford, too, has given a salutary warning to university empire-builders. We should be spared the spectacle of heads of postgraduate departments having to canvass for and accept students of less than degree standard to build up classes of adequate size. University expansion must go hand-in-hand with expansion of educational facilities in all kinds of schools and in industry itself. Technologists are of little use without technicians who, in turn, need craftsmen to serve them. There are many who feel that, desperate as is our plight for technologists, in ten years time our greatest deficiency may be the lack of adequately trained technicians and craftsmen.

THE PROFESSION OF SCIENCE

The Organisation of Science in England

A Retrospect. By Dr. D. S. L. Cardwell. (Heinemann Books on Sociology.) Pp. ix+204. (London: William Heinemann, Ltd., 1957.) 18*s*. net.

IT was not for want of urging that Englishmen have been slow to appreciate the educational implication of the revolution initiated by applied science. As early as 1832 Baden Powell, Savilian professor of geometry at Oxford, condemned the practice of allowing graduates to leave the university ignorant of science. Lectures in chemistry and experimental philosophy were, in his time, losing their appeal, and the proportion of those taking honours in mathematics was also steadily falling. He ascribed it to the faulty education provided by the schools. Charles Babbage, Lucasian professor of mathematics at Cambridge, was even more outspoken and, two years before, in "Observations on the Decline of Science in England", lamented that "the pursuit of science does not constitute a distinct profession as it does in other countries".

To obtain professional status for scientists, Dr. Cardwell argues there had to be a series of changes in the educational system. "The professional scientist," he writes, "is, in the first instance, the product of the educational system; to a much less extent is he the product of industrial practice and economic organisation."

This book is written around the provocative thesis that industry did not demand professional scientists until the universities produced them. In other words, the first professional scientists produced were teachers, and the present voracious appetite which industry exhibits for professional scientists has grown with feeding. To support this thesis, Dr. Cardwell has combed the nineteenth-century journals, *Nature* included. He rightly gives full credit to Liebig and Helmholtz for helping to convert the English to a need to train scientists. They exported men and ideas in the eighteen-forties. The men included Caro, Fischer, Fries, Bopp, Griess, Geyger, Kolbe, Leibius, Holtzmann, Ulrich, Martius, Olshausen, Wilbrand, Sell and Witt: the first of these only left England in 1867 and the last in 1879. During this period they served English industry and science before England was producing men of similar calibre. For the fine crop of projects for industrial universities and even ministries of science which Dr. Cardwell has exhumed needed rooting in good schools, and sustentation by a capacity-catching (or capacity-attracting) system. Neither was available.

So, to slake what the *Edinburgh Review* called "the sacred thirst for science", there arose the mechanics institutes: those 'steam intellect societies' that evoked the post-prandial jokes of the upper class. Baden Powell, watching their spread, remarked that unless the upper class followed suit, "that class will not long remain the *higher*". By the time of the Great Exhibition, plans were afoot to federate the mechanics institutes into a national network of colleges of technology. Soon after, the Government created the most formidable instrument for scientific education to date—the Science and Art Department. This Department did much to tap "the vast reservoir of unfriended talent" (as the Rev. James Booth called it) that lay stagnant in Victorian England. Aptly enough, access to this reservoir was obtained by Sappers: officers of the Royal Engineers were employed by the Science and Art Department as school inspectors and examination supervisors. The most distinguished of these, John Donnelly, rose from captain to major-general in the process of tapping this reservoir: he enjoyed throughout his professional life the friendship of T. H. Huxley, and earned at his death an obituary in *Nature*. The Army also nourished Col. Alexander Strange, Fellow of the Royal Society, who insisted that only the State could adequately support the advance of science. As Dr. Cardwell writes, "it is a testimony to his judgment that practically everything he called for has, today, been realised". It is the story of this realization which provides the core of Dr. Cardwell's book, and it should be read by all those whose professional ancestry he has sketched with such intimate detail.

W. H. G. ARMYTAGE

VETERINARY OPHTHALMOLOGY

Veterinary Ophthalmology

By R. H. Smythe. Pp. xii+356+15 plates. (London: Baillière, Tindall and Cox, Ltd., 1956.) 35*s*. net.

THIS book will be welcomed by veterinary surgeons, students and others interested in the mammalian and avian eye. The work presents, in the form of a concise and readable text-book, the existing knowledge of ophthalmology as it may be applied to the study and treatment of animals. The book

is in two parts. The first deals with the anatomy and physiology of the eyes of various animals. The domestic animals are dealt with in detail, and in addition reference is made to birds, fish and reptiles. The sections on animal vision and the optical system are compiled very well, and the author has correlated the work of others and contributed the results of his own observations.

The second part of the book is devoted to the clinical aspect and consists of two hundred pages. All aspects of veterinary ophthalmology are reviewed, and methods which have stood the test of time as well as new treatments are described. This section is introduced with a description of the clinical examination of the eye followed by chapters dealing with anatomical regions of the eye. Clinicians and students will find this a valuable source to which to refer, especially with regard to the incidence, diagnosis and medical treatment of the conditions described so comprehensively. The surgical references are somewhat disappointing. No method of extirpation of the eyeball which might give promise of first intention healing is described. Many methods of dealing with entropion and ectropion are detailed and these defects, which are usually simple to treat, are made to appear complex. Extraction of the crystalline lens in the dog, on the other hand, seems simpler than most would agree. The book ends with fairly complete chapters on therapeutics and ophthalmic preparations in daily use.

It is hoped that the next edition might have the references removed from the text and placed at the end of each chapter. Some chapters, particularly that dealing with methods of examination, could be given titles of greater clarity.

Despite these few criticisms the wealth of information in this book, which is full of illustrations, line drawings, photomicrographs and photographs, should be studied by all who are interested in advancing their knowledge of veterinary ophthalmology. The author has filled a need, and the publishers should be congratulated on their part of the task.

C. Frost

CHEMISTRY AND TECHNOLOGY OF WOOL-WAX

Wool Wax

Chemistry and Technology. By Dr. E. Vernon Truter. Pp. xi+368. (London: Cleaver-Hume Press, Ltd., 1956.) 60*s*. net.

In the preface to his book, Dr. Truter expresses the hope that this work—the first comprehensive and critical account of the chemistry and technology of wool-wax—will help to encourage further research and development on this most interesting subject. Undoubtedly the author has succeeded in presenting the subject in a most instructive manner and should, by virtue of this, provide a stimulating influence to prospective workers in his field. The diversity of subjects covered may be indicated by the fact that the topics discussed vary from the structure of the wool follicle to the stereochemistry of clathrate compounds and that there are 571 references.

The contents of the fleece and their distribution, and the factors affecting these variables are discussed fully in Chapter 1. Chapter 2 deals with the chemical constitution of the wax and describes the large amount of work that has been carried out on this subject in the past decade. The constitution and uses of suint, the water-soluble portion of wool-wax, merits a chapter on its own. There follows a critical discussion of the physical chemistry of oil–water emulsions which is aided by several photomicrographs and clearly drawn diagrams. The derivation and utilization of the principles involved in the recovery of wool-wax from oil-in-water and water-in-oil emulsions follow quite naturally, as does the account of the various saponification processes.

Of particular interest is the space devoted by the author to a discussion of the isolation, purification, determination and properties of cholesterol and isocholesterol. No fewer than 146 of the 356 pages are devoted to these topics. The chapter in which is described the preparation and uses of clathrate compounds ("Sorting Molecules by Size and Shape") is particularly interesting, albeit it suffers from a slight surfeit of thermodynamics. In the chapter entitled "Lanostane Derivatives" is given a comprehensive account of the step-wise elucidation of the structure of the one-time *bête noire* of the triterpene chemist, 'lanosterol'. The account is presented logically and is helped in no small measure by a generous recourse to diagrammatic reaction schemes which are clear and unambiguous.

The chapter on steroidal derivatives begins with a short account of the stereochemistry of the steroid nucleus. This would have been better placed in the previous chapter on lanostane in order to explain the stereochemical notations used, for they are common to both classes of compounds. This chapter might be considered a valuable adjunct to the standard book of reference "Natural Products related to Phenanthrene" by Fieser and Fieser, since about half the references cited are later than 1949—the date of the last edition. After a very enlightening chapter which describes the remarkable 'Bradford Recovery Process' for the recovery of wool-wax from the city effluents, there are listed the many and varied uses of the wax in various states of purity. Space is also devoted to an account of the destructive distillation and vacuum distillation of wool-grease.

The book is written in a lucid and unassuming style, and is gratifyingly free from misprints; as a source of reference for workers on wool-wax and allied fields it should prove a valuable asset.

D. A. Lewis

MEASURE AND INTEGRAL

Mass und Integral und ihre Algebraisierung

Von Prof. C. Carathéodory. Herausgegeben von P. Finsler, A. Rosenthal und R. Steuerwald. (Lehrbücher und Monographien aus dem Gebiete der Exakten Wissenschaften. Mathematische Reihe, Band 10.) Pp. 337. (Basel und Stuttgart: Birkhäuser Verlag, 1956.) 38.50 francs; 38.50 D.M.

This is a charming book; all mathematicians must regret that it is the last we shall have from its distinguished author. For some twenty years, in a series of papers, Carathéodory worked at the construction of a theory of measure which should start from the concept of a set of objects for which Boolean addition, multiplication and complementation could be defined, and should proceed from there to a measure theory and a definition of the integral, the Boolean ring playing a part analogous to that of the

point function. In fact, it is possible to trace the first steps of this programme in his delightful "Vorlesungen über reelle Funktionen" (1918), to which those students who came fresh to real variable theory just after the First World War owe a great debt of gratitude. Fortunately, Carathéodory lived long enough to gather up into a systematic and self-contained account the half-dozen or so papers in which he developed his programme, and this volume has all the clarity, elegance and power which we had come to expect as a matter of course from his pen. The elegance is particularly shown in the chapter introducing the theory of measure, and the power is exhibited effectively in the chapter which deals with limit processes, convergence in the mean, and culminates in an admirable account, following H. R. Pitt, of G. D. Birkhoff's ergodic theorem.

Although we may feel that this is a classic exposition marking the close of an era, rather than the crude but stimulating signpost to unexplored domains, its urbanity and charm cannot be denied; no one save possibly de la Vallée Poussin has written so attractively about the real variable.

T. A. A. BROADBENT

MARINE CREATURES

Window in the Sea

By Ralph Nading Hill. Pp. 240+24 plates. (London: Victor Gollancz, Ltd., 1956.) 18*s*. net.

The Living Sea

By John Crompton. Pp. 256. (London: William Collins, Sons and Co., Ltd., 1957.) 15*s*. net.

Creatures of the Deep Sea

By Klaus Günther and Kurt Deckert. (Translated by E. W. Dickes.) Pp. 222. (London: George Allen and Unwin, Ltd., 1956.) 18*s*. net.

Adventuring with Beebe

Selections from the writings of William Beebe. By Dr. William Beebe. Pp. xii+284+8 plates. (London: The Bodley Head, 1956.) 18*s*. net.

The World of Water

By Dr. J. Gordon Cook. (Science for Everyman.) Pp. 192+8 plates. (London: George G. Harrap and Co., Ltd., 1956.) 12*s*. 6*d*. net.

FAR from causing a decline in reading, as was once predicted, it is now becoming evident that television has led to a greatly increased sale of books dealing with topics which have proved popular on the screen. This is perhaps most evident in archæology, but it is becoming noticeable in other fields too. The growing sport of undersea swimming has reinforced the demand for books about sea life, the publication of which has received a further fillip from the film and television successes of Hans Hass and Jacques Cousteau. We cannot blame the publishers for trying to satisfy this demand, but we can blame them for publishing books seemingly written in haste merely to profit from this fashion. The past twelve months have seen the publication of several excellent works on sea life, but of the five here reviewed only one is really to be recommended. "Window in the Sea", a description of the genesis and functioning of the 'Oceanarium' in Florida, is clearly intended as an extended piece of journalism, written by someone well versed in his craft, and as such succeeds admirably. To the marine biologist it affords tantalizing glimpses of the functioning of this overgrown aquarium, and it has a few minor errors of fact, but I found it of absorbing interest. The prose has a compulsive quality, the construction is as tightly woven as a good detective story and the subject is of both popular and scientific interest.

"The Living Sea" is a more pretentious piece of writing, in essence again a piece of journalism, but disguised. I receive the impression that Mr. Crompton has hurriedly read up marine biology in order to write a book on a subject which will sell. Mistakes of fact abound; for many pages together not one may be found free of error. That an author should attempt a book on sea life without knowing or finding out what is meant by 'plankton' is truly astounding. "The Living Sea" is illustrated by twenty-four uninformative, badly executed line drawings, nearly half of which deal with land animals. By contrast, "Creatures of the Deep Sea" is copiously illustrated, entirely by well-conceived and executed line drawings. It is, however, apparent that these are the same blocks, now well worn, that were used for the original German edition seven years ago. Perhaps the economy is justified in a lower price, but the drawings deserve better printing. Indeed, the chief merit of this English edition lies in the drawings, but any student with access to a library copy would be well advised to use the original German edition, printed before the blocks were so worn. For a work so evidently intended for students this book is thoroughly out of date. If it had been written for the general reader this would not matter so much, but even in 1950 it was a trifle behind the times. The seven years which have elapsed before the appearance of the translation have seen the publication of enough of the results of the *Galathea* and *Albatross* deep-sea expeditions to revolutionize our knowledge of this field. The publishers are at fault in commissioning this translation, which is moreover little more, in places, than a transliteration: some of the sentences even have the verb at the end, and one is conscious throughout of the Germanic construction. Mr. Dickes evidently is no marine biologist; he does not know the English names of fishes or of fishing gear, however well he may know the German. Teufelfisch and devilfish, for example, are by no means the same thing: they are not even in the same phylum. Nor is a trawl a townet. The book provides a reasonable summary (provided we take heed only of the scientific names) of our knowledge of deep-sea fish as it was ten years ago. It is much less good on invertebrate groups, which are, of course, of the greater importance in the economy of the extreme depths. As a picture gallery of biological curiosities it does fulfil a useful function.

The same cannot be said of "Adventuring with Beebe", which consists of isolated chapters reprinted from earlier books by Dr. Beebe. I cannot believe that Dr. Beebe supervized the publication of this hotch-potch. It is pleasant to meet again his elegant if sometimes over-fanciful prose, but the sudden jumps from subject to subject, with missing antecedents, are disconcerting. A re-issue of "Half a Mile Down", the account of his bathysphere descents, would have been acceptable, but these extracts are not. Nonesuch Island loses its fascination when treated in this cavalier manner. This is a book published to profit from a passing fashion.

"The World of Water" is free from this taint. It is one of a series designed to inform the general reader on scientific topics of the day. It is badly produced and

the title page is one of the worst examples of typography I have seen for many years. Yet where he is writing on subjects which he knows, Dr. Cook is readably informative. His prose style is incisive (unlike the type face) and runs smoothly. But he is an industrial chemist; and to him water is a chemical substance and the raw material, in varying degrees of purity, of many chemical, engineering and industrial processes. It is an unfortunate accident that certain uninteresting creatures live in this otherwise cleanly compound, and so Dr. Cook sets manfully about describing them. In three very brief chapters he dismisses aquatic life, chiefly in disconnected paragraphs of one sentence apiece. He has culled his facts from the text-books and served them out half-digested and very condensed on to the page. Facts treated like this have a regrettable habit of ending no longer as facts, or at best as quite unintelligible. Dr. Cook should stick to departments of science where his digestion works better. In his own field he writes well and clearly. These three chapters aside, "The World of Water" probably fulfils its aim of informing the general reader.

D. B. Carlisle

LINNAEUS AND THE ANIMAL KINGDOM

Caroli Linnaei Systema Naturae

Tomus I: Regnum Animale. (A Photographic Facsimile of the First Volume of the Tenth Edition (1758).) Pp. v+824. (London: British Museum (Natural History), 1956.) 42*s*.

THE publication by the Trustees of the British Museum (Natural History) of a fresh facsimile edition of the tenth edition of the "Systema Naturae" of Linnaeus—the volume in which Linnaeus dealt with the animal kingdom—meets a real need, copies of this essential work having become increasingly difficult to obtain.

In many fields a work which, in its day, was of importance by reason of the novelty of the ideas put forward or of the techniques adopted for the marshalling and presentation of existing knowledge, it outwears in time its practical utility until at last it becomes little more than an interesting landmark in the history of the subject. This, however, cannot happen in the case of works concerned with systematic zoology, owing to the fundamental part played by nomenclature in this field. That this should be so is due to two causes. First, it was in this volume that Linnaeus introduced the binominal system of nomenclature, which distinguishes it from any previous work in the field of descriptive zoology. It is for this reason that the present International Code provides (Article 26) that the publication of this volume in 1758 is to be treated as the starting point of zoological nomenclature. Second, the Code enshrines (Article 25) the principle originally propounded by Linnaeus for the naming of plants but later extended by him to the naming of animals that, other things being equal, the oldest name for any taxon is its valid name. Systematic zoology is thus to a considerable extent a historical subject, the specialist constantly finding it necessary in the course of his strictly zoological work to refer back to the published literature. For these reasons the tenth edition of the "Systema Naturae" is a basic source-book, for the 312 generic and 4,300 specific names employed by Linnaeus in this volume are the oldest available names for the taxa concerned and, save in a few special cases, are the valid names for those taxa and are accordingly to-day in universal use.

Notwithstanding the importance of the "Systema Naturae" of 1758 from the foregoing point of view, it might be thought that almost the last drop of value had been squeezed out of that famous work by the zoologists of the past two centuries; but this is not so, for the development long after Linnaeus's day of the subspecies concept necessitated a detailed re-examination of the original descriptions of all the older-described polytypic species in order to determine which of the known subspecies should be accepted as the nominate subspecies. Until recently, such studies presented serious difficulties, but these have been greatly eased by the provision by the Fourteenth International Congress of Zoology, Copenhagen, 1953, of rules both for the designation of lectotypes for nominal species established without holotypes and for the designation of 'restricted localities' for such species. These decisions call for a detailed re-study of the tenth edition of the "Systema Naturae", and from this point of view alone the publication of a facsimile edition at a moderate price is particularly opportune. Fundamental in importance as is the tenth edition, the twelfth and thirteenth editions are almost equally essential to the working systematist, and both are now costly and difficult to obtain. The twelfth edition was regarded by Linnaeus as crowning his work in systematic zoology, while the thirteenth edition, edited by J. F. Gmelin after the death of Linnaeus, contained many important additions to his published work.

Zoologists are greatly indebted to the Trustees of the British Museum for publishing the present facsimile, and they would be even more indebted if the Trustees could see their way to treat the present as being the first instalment of a series of such editions of basic historical works on systematic zoology.

Francis Hemming

MODERN TECHNIQUES OF BLOOD TRANSFUSION

Blood Transfusion in Clinical Medicine

By P. L. Mollison. Second edition. Pp. xxvi+587. (Oxford: Blackwell Scientific Publications, 1956.) 45*s*. net.

IN preparing this new edition, Dr. Mollison has skilfully sifted the voluminous literature of the past five years and has incorporated every significant advance in the clinical practice of blood transfusion, blood group serology and laboratory technique. As Dr. Mollison states, "just what is relevant to the subject of Blood Transfusion must necessarily depend to a great extent on the knowledge and interests of those who practise it", but those who are unfamiliar with the first edition will find that the author's interests and knowledge of his subject are such that this book contains sound and clear guidance on every problem which clinicians or pathologists may encounter in blood transfusion.

Many of the advances in knowledge have come from the Blood Transfusion Research Unit at the Postgraduate Medical School of London, of which Dr. Mollison is director, in developing procedures such as the measurement of the survival of red cells *in vivo* by the

technique of labelling with radioactive chromium and the preservation of red cells for indefinite periods in the frozen state. Authoritative and up-to-date accounts are included, therefore, of these new techniques. Other new sections cover the effect of purine nucleosides on blood storage, hypo-gammaglobulinæmia, transfusion in injured patients, plasma substitutes, auto-antibodies in acquired hæmolytic anæmia, patterns of destruction of incompatible red cells, and citrate and potassium toxicity. The chapters on the blood of new-born infants and hæmolytic disease of the new-born will be of particular interest and value to pædiatricians, and detailed accounts are given of ABO hæmolytic disease and of the techniques of simple and exchange transfusion. The book concludes with a comprehensive and up-to-date list of references extending to forty-nine pages.

This second edition will enhance still further the reputation established by the first edition in 1951 and can be strongly recommended as an essential work for clinicians, pathologists and research graduates concerned with blood grouping and blood transfusion. It is too detailed and advanced for general use by undergraduates, but these also would obtain much vital information from a study of those sections concerned with clinical aspects, such as transfusion in hæmorrhage, anæmia and disorders of blood clotting, and the ill-effects of transfusion.

G. H. Tovey

NUCLEAR SCIENCE

Annual Review of Nuclear Science

Edited by James G. Beckerley, in association with Martin D. Kamen and Leonard I. Schiff. Vol. 6. Pp. viii+471. (Palo Alto, Calif.: Annual Reviews, Inc., 1956.) 7 dollars.

THIS latest volume of the series maintains the high standard of the preceding ones. Thirteen review articles by experts in the fields range from cosmic rays to radiobiology. For the non-specialist about half the articles may prove heavy going. These are usually the articles where the authors attempt to review exhaustively all the literature of the past year or two. The reviews which attempt to see a problem whole, and to assess our present knowledge of it, are much more satisfactory.

The present state of our knowledge of time variations of primary cosmic rays is summarized by Sarabhai and Nerurkar. This is a most interesting branch of cosmic-ray studies because of its possible connexion with the origin of the cosmic rays—still one of the outstanding astrophysical puzzles. Polarization of fast nucleons, by Wolfenstein, reviews the theory and illustrates this with the experimental data recently assembled for nucleon energies between 100 and 400 MeV. Coulomb excitation of heavy nuclei by relatively low-energy charged particles has been one of the really new advances in low-energy nuclear physics. This field is summarized by Heydenburg and Temmer, who have contributed so largely to the experimental work on this subject. The properties of medium weight nuclei between neutron numbers 22 and 90 are reviewed by Way, Kundu, McGinnis and van Lieshout. This is the group under Dr. Way whose tireless efforts at compiling nuclear data keep every nuclear physicist in her debt. The range of nuclei they discuss is that interesting region where the nuclei are too heavy to be simple structures and too light to act in a simple way collectively. The isotope shift in atomic spectra is discussed briefly by Mack and Arroe and the method of extracting nuclear masses from reaction data is described by Mattauch, Waldmann, Bieri and Everling. A technical article on recent advances in low-level counting by Anderson and Hayes describes in particular the large liquid scintillator systems devised to detect the neutrino. For the chemists the concept of generalized acidity in radiochemical separations has become of great importance in connexion with the atomic energy field. This subject is reviewed by Horne, Coryell and Goldring. How oxygen isotopes can be used as tracers in chemical studies is described by Taube. Reactor physicists will be most interested in a review of the crucial field of radiation effects in solids by Brooks and in a compilation of the nuclear reactors being built or thought of throughout the world for power generation. The latter article by Davidson, Loeb and Young treats some twenty-seven types in some detail but may well be out of date even now. Two radiobiology articles complete the volume: cellular radiobiology by Gray, and vertebrate radiobiology by O'Brien. Radiobiology is undoubtedly a subject in which all scientists need to be better informed.

E. B. Paul

LIVER-FLUKE SNAILS IN BRITAIN

Liver-Fluke Snails in Britain

By Dr. Alan Mozley. Pp. xii+55. (London: H. K. Lewis and Co., Ltd., 1957.) 9*s*. net.

TO those already familiar with Dr. Mozley's other books in this series the present volume will need little introduction or explanation. The book is concerned with the location, identification and control of *Lymnaea truncatula* in Britain. The author describes several walks through unidentified areas of England, Scotland and Wales during the course of which an account is given of the sites in which the snails are found. In his preface Dr. Mozley states that the book is intended for veterinarians, advisers and farmers. He follows this by a statement of the admirable principle that neither scientists nor technologists should feel it undignified to write in ordinary language. Unfortunately, Dr. Mozley has gone to the opposite extreme and fallen into the trap of 'talking down' to his readers.

The remarks on identification of the snails suggest that there is no possibility of confusion with other species, but unfortunately this is not the case, and in view of this fact it is a pity that the instructions relating to the preservation of specimens for identification do not include some elementary information on the fixation of material for anatomical examination by experts. Some of the half-tone illustrations of habitats are reasonably good, since such sites are notoriously difficult subjects for black-and-white photography.

I find it difficult to share Dr. Mozley's optimistic outlook on the ease with which snail eradication will be achieved. There is no doubt that the sites he describes as centres of snail development are the most important from the aspect of fluke transmission, but there is little doubt that there is a usually undetected reservoir snail population from which these foci will rapidly be repopulated under suitable conditions.

C. A. Wright

The Theory of Games and Linear Programming

By S. Vajda. Pp. 106, with 14 diagrams. (New York: John Wiley and Sons, Inc.; London: Methuen and Co., Ltd., 1956.) 8*s*. 6*d*. net.

THIS book provides a useful introduction to linear programming and to the terminology and basic concepts of games theory for those who have a reasonable knowledge of matrix algebra and analytical linear geometry. Newcomers to these subjects should find the text and mathematics easy to follow despite a cumbersome use of subscripts intended to provide a generality that is not needed. Chapters 1 and 4 in particular give a sound outline of games theory and linear programming, respectively, with a minimum of mathematics.

Linear programming is treated in a straightforward and commendable manner. The common problems that occur (for example, degeneracy) are discussed in some detail and four methods of calculating the solution of a linear programming problem are given —the simplex and dual simplex methods, the method of leading variables proposed by E. M. L. Beale and an 'inverse matrix method', apparently Dr. Vajda's own invention.

The theory of games receives scant treatment by comparison. Only one type of game is discussed—the two-person zero-sum game—and that is employed mainly to provide examples of a use to which linear programming methods may be put. Little mention is made of other types of game. Two proofs of the minimax theorem are included; one being the proof given by von Neumann. Numerous simple numerical examples are given to illustrate the text. Discussion of the practical applications of linear programming is necessarily restricted by the size of the book. The references given at the back of the book provide a useful basis for further study. P. R. Fisk

Inorganic Qualitative Analysis

Semi-Micro Methods. By H. Holness. Second edition. Pp. vii+152. (London: Sir Isaac Pitman and Sons, Ltd., 1956.) 12*s*. 6*d*.

THE author of this little book is well known as an enthusiast on his subject, and this volume is based on long experience with students and their difficulties. It describes the equipment necessary for students working up to a pass degree standard and, as economy has been kept in view in the selection and design of the apparatus, it should have a wide appeal to school science teachers. In fact, I have reason to know that many schools already use the apparatus and methods herein described.

It is sometimes urged, usually by people who have not studied this type of approach, that semi-micro-methods tend to destroy the didactic value of a systematic course of analysis and to replace it by a series of more or less selective 'spot' tests. This book should dispel that idea, for the analytical scheme is essentially the time-hallowed Fresenius group scheme with certain distinct improvements, many of them due to the author. The methods of separation and the confirmatory tests are clearly described, and there is a wealth of helpful advice on many points which are apt to puzzle students. The technique is such as to instil the necessity for clean and careful working, and the author claims—and rightly—that large classes can carry out their work with a minimum of smell and personal movement. The book is well produced on good paper and appears to be free from misprints.

A. D. Mitchell

Hydrodynamics

By Hugh L. Dryden, Francis D. Murnaghan and H. Bateman. Pp. iii+634. (New York: Dover Publications, Inc., 1956.) 2.50 dollars, paper bound.

THIS book was originally published by the United States National Research Council in 1934. It is in four parts. The first and shortest part, by all three authors, deals with the basic physics of fluids and classical hydrodynamics. The formulæ for divergence, etc., are derived, but the major part is an account of the types of flow to which classical perfect fluid and viscous fluid theories apply. The rest of the book is all by H. Bateman. The second part is on the motion of an incompressible viscous fluid, the third on turbulent flow and the last on compressible fluids. It is not a book for beginners in hydrodynamics but an excellent one for reference to many special types of flow. The emphasis is on application to hydraulics and aerodynamics. It is not geophysical; tidal waves are not mentioned. It contains the initial stages of the statistical theory of turbulence. The bibliographies are excellent and so are the subject- and author-indexes. The only illustrations are clear line drawings. The book is now, of course, out of date, but as a reference book in its field up to 1934 is a very useful addition to this excellent series of reprints which already includes the sixth (last) edition of Lamb's "Hydrodynamics". The only complaint is that the binding, which is stapled, is too tight so that the book must be forcibly held open. G. A. Bull

Symposium on Monte Carlo Methods, held at the University of Florida, March 16 and 17, 1954

Edited by Herbert A. Meyer. (A Wiley Publication in Applied Statistics.) Pp. xvi+382. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 60*s*. net.

THE first symposia on Monte Carlo methods were held during 1949–50, when, in addition to the description of early successes, much time was spent on definitions. To-day, discussion of the definitional problem, as A. W. Marshall observes in his excellent introduction to the present volume, is largely beside the point. In the symposium under review we see the Monte Carlo method in its full vigour, accepted for a wide range of problems in statistics, physics, biology, game theory, engineering, and insurance. It is greatly significant of its extensive importance that in the last paper we read of first-year students at Darmstadt's Institut für Praktische Mathematik learning to estimate integrals by a Monte Carlo method immediately after having discovered what an integral is.

The remaining eighteen papers are a stimulating but heterogeneous collection. The expert will find much of interest and the novice (for whom no book has yet been written on the foundations of Monte Carlo) may approach without fear: the introduction and the paper by Curtiss (a detailed comparison of 'classical' and Monte Carlo approaches to the solution of linear equations) expose the fundamental attitude of Monte Carlo with great clarity. In addition to the applications already mentioned, there are papers on the generation of random numbers, techniques of variance reduction, and a conditional sampling technique by means of which 1,000 random numbers do the work usually designed for 5 million. The book ends with an extensive bibliography which includes many abstracts. D. M. G. Wishart

NATURAL SELECTION IN ACTION IN *EUCALYPTUS*

By Prof. H. N. BARBER and W. D. JACKSON
University of Tasmania

DURING the past twenty years the genetical theory of natural selection has become the dominating theory of evolutionary mechanism. Its dominance is probably greater to-day than was that of Darwin's own theory in the years before the anti-Darwinian revulsion of the late nineteenth century. The reasons for this are quite clear. Genetical theory has allowed us to put on a quantitative basis the processes of natural and artificial selection so that we can measure the coefficient of selection (or Darwinian fitness) for any one member of an allelic series of genes with reference to a chosen standard allele. Basically the methods for measurement are of two kinds—the dynamic method in which changes of gene frequency over a number of generations are measured, and the static method where the conditions of selection determining a stable set of gene frequencies in a population are analysed.

The dynamic methods have been successful in giving some estimate of coefficients of selection over periods of tens or hundreds of generations as in industrial melanism in moths[1], colour polymorphs in rabbits[2], etc. They have also been successful over much shorter periods of time where it has been possible to demonstrate considerable regular and cyclical, for example, in *Drosophila*[3], or irregular, for example, in the moth *Panaxia*[4], fluctuations from generation to generation in the magnitudes of selective coefficients.

The static methods are of three main types. The first involves a study of conditions determining a polymorphic equilibrium in a population under a more or less uniform environment. The condition for a stable equilibrium with two or more alleles in the population involves a heterotic effect, for example, inversions in *Drosophila*[3], blood groups, hæmoglobin types, etc., in human populations[5]. In these cases it is possible to measure the Darwinian fitnesses of both homozygotes against the heterozygote taken as standard. In the second static method the equilibrium involves a balance between the selective elimination of unfavourable genes and the production of the same gene by mutation. If we can measure the mutation-rate and the equilibrium frequency of the alleles, we can calculate the coefficient of selection and vice versa. This method has been applied successfully to populations of flies and human beings[6]. The third static method involves the analysis of clinal change in gene frequency. It has been used in populations of clovers, eucalypts, snails and mammals[7]. The cline may be determined either by a gradual change in selective coefficients along an ecological gradient or by random migration of genes in gamete or zygote across a sharp ecological barrier or by both factors combined. Clinal changes in gene frequency may have to be considered over distances of yards as in the snails, hundreds of yards as in the eucalypts or hundreds of miles as in the clovers, fruit flies and human beings.

In many populations it is possible to apply a variety of these methods in the estimation of coefficients of selection. Where one of the static methods shows large selective coefficients, transplant experiments or the population cage can be used to measure the coefficient of selection dynamically. The classical example is the work on the heterotic inversions of *Drosophila pseudo-obscura*; but the detailed medical investigation of the varying chances of disease among the different blood groups and hæmoglobin types is another basically similar approach.

Clinal analysis of glaucousness in several of the Tasmanian species of eucalypt has indicated very high selective coefficients for the genes controlling this characteristic[8]. The non-glaucous (green) phenotypes are characteristic of the more sheltered ecological habitats, the glaucous phenotypes becoming more frequent the more exposed the environment. Thus in species like *E. gigantea*, *pauciflora*, *salicifolia*, *gunnii*, *urnigera*, etc., the populations at the lower altitudinal range are usually uniformly green, while at the upper altitudinal limit they are uniformly glaucous. The change may be complete over an altitude of 400–500 ft. ($\frac{1}{2}$–1 mile in ground distance). This means that the genes controlling glaucousness are, from an evolutionary point of view, lethal in the sheltered habitats but essential to survival in the exposed. So far as is known, these clines are in equilibrium with the present environment. Nothing is known about the rate of their establishment from a uniform mixed population. However, this spectacular and delicate response to selection has made it seem likely that a direct measure of the selective coefficients per generation by one of the dynamic methods would be worth while.

There are two ways of approach, both of which are being tried on populations of *E. urnigera* from Mount Wellington (Hobart). The first is the transplant method. Twelve progenies from mothers of known phenotype and altitude have been planted in two latin squares for studies of growth- and survival-rates. It will be several years before results are available. Half the mothers used were segregating both green and glaucous seedlings, so it will be possible to test any differences in growth-rate or survival between seedlings of the one progeny and between different progenies. It is hoped to use several different habitats for experiments of this nature.

The second approach has given immediate results. There is little direct evidence on the mating system operating in eucalypt forests. Earlier workers have usually assumed predominant selfing. However, the pronounced protandry in many species and the genetic segregation observable in seedlings from the one mother point to out-breeding. The known pollinators include many strong-flying insects and birds such as honey-eaters and parrots. *E. urnigera* flowers in the late autumn. Its flowers, with their urceolate receptacle which may overflow with the copious nectar, are often visited by flocks of birds. Thus, the mean free path of a pollen grain may be considerable compared with the inter-quartile dis-

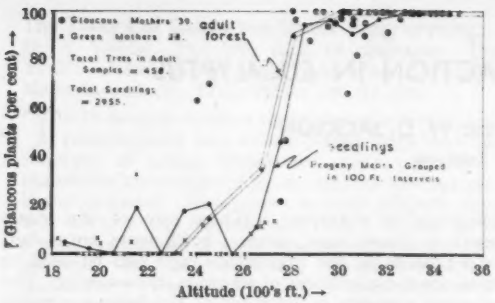

Fig. 1. Clinal variation in glaucousness in *Eucalyptus urnigera*, Mount Wellington, Tasmania

tance of the cline (about 100–200 ft. in altitude). Under these conditions a direct demonstration of natural selection in action appeared to be possible.

The plan adopted was simply to measure the frequency of green and glaucous trees in the adult forest and also in seedlings raised in the experimental garden from open-pollinated mothers from known altitudes. The sampling procedure adopted for seed-collection was to cover the whole altitudinal range of the species from 1,900 to 3,500 ft. Sixty-seven mothers were chosen at intervals of 20–50 ft. From each mother, fifty seedlings were pricked out into tubes and grown for six months until scoring was possible. Survival-rate and germination of seed varies considerably between mothers, but at the time of scoring 2,955 seedlings were available (an average of 44·1 per mother; minimum 20, maximum 60). The results are given graphically in Fig. 1. It will be seen that of the 28 green mothers 12 segregate glaucous seedlings, while of the 39 glaucous mothers 17 segregate green seedlings. This is strong evidence of outcrossing. The only other explanation is a strong heterotic system based on multiple dominant inhibitors of glaucousness at low altitudes and multiple recessive greens at high altitudes. This seems unlikely. It is hoped to study the inheritance of glaucousness in more detail. Dominant or incompletely dominant glaucousness is known in several species or species crosses. Recessive glaucousness has not been reported.

Whatever the precise details of inheritance of glaucousness, Fig. 1 shows immediately natural selection in action. The cline in seedling frequencies is less steep with longer tails at top and bottom than is the cline for adults. If the adult cline is in equilibrium, this means that we must postulate that at the bottom of the cline glaucous seedlings are eliminated by natural selection as the forest matures, and at the top end green seedlings are eliminated. In other words, the selective coefficients per generation show almost the maximum possible change in value over less than 1,500 ft. change in altitude.

The raising of these sixty-seven progenies in the uniform environment of the garden has proved that several gene differences controlling glaucousness are segregating along the cline. Progenies and seedlings within the one progeny may differ in both intensity and pattern of glaucousness. Intensity is usually highest in the half-expanded leaves of all types. In some seedlings the wax rapidly fades as the leaves mature, while in others it persists on mature leaves, probably because the adult leaves continue to secrete the wax. Scoring of these variations is difficult, but it is clear that clines in the genes controlling intensity and pattern are present, intensity and spread of glaucousness increasing with increasing altitude.

There were several other variable characteristics in the seedlings. Some of these show indication of clinal change. In adult trees the leaves change from long falcate in the lower populations to blunt oblong in the upper forests. Transplant experiments have shown that this difference is heritable. The seedling leaves were scored for shape as measured by length/breadth ratio and apex shape (pointed or blunt). The data on length/breadth ratio have not been fully analysed; but there are strong indications of a change in apex shape from pointed to blunt as the altitude of collection increases. However, at this stage of growth variability is large. Similarly, the seedlings vary in degree of smoothness of the stem. From 1,800 to 2,800 ft. there is little change in this characteristic, the percentage smooth-stemmed seedlings remaining at about 20. But above 3,000 ft. the proportion rises to 50 per cent. Variability within and between progenies is still high. There is an indication of a third clinal variability affecting pattern of growth. During the first winter, the seedlings from the parents at high altitudes tended to go into dormancy earlier than those from low altitudes. No detailed scoring of this characteristic has been made. It is hoped to follow all these characteristics in older seedlings to check these findings. But there appears little doubt that the response to selection in this species involves correlated changes in leaf colour, leaf shape, stem surface and timing of growth, the response in leaf shape and stem surface being controlled by lower selective forces operating on the genes concerned.

The results of this study of natural selection agree with those of many other recent investigations[7] in showing the existence in Nature of selective coefficients of a high magnitude (5–100 per cent) affecting genes controlling a wide variety of apparently trivial characteristics. The selective coefficients show great changes in value with change of habitat. Our investigations add the fact that correlated responses in several different characteristics can be built up by natural selection acting along the one ecological gradient.

The significance of these observations is generally unappreciated. Natural evolutionary processes are usually discussed against the background of small differences in selective coefficients. Thus Wright[8] states: "It is probable that most of the mutations which are important in evolution have much smaller selection-coefficients than it is practicable to demonstrate in the laboratory". The main reason for this belief is the knowledge that evolutionary processes have had the whole of geological time to do their work of creating the diversity of the present fauna and flora. In this abundance of time, there is no need for large selective coefficients. This view overlooks the widely fluctuating environments under which populations of almost all living organisms have had their being. The new knowledge of selective processes immediately raises two problems: How important are the fluctuations in selective forces in long-term evolutionary processes, and what is the functional significance of the genes concerned?

As regards the first problem, it is clear that strong selection itself, far from bringing uniformity to a species population, can build up great genetic diversity, even in the face of considerable immigra-

tion of genes. Whether or not Wright's idea that local, partially isolated, populations of the one species provide the conditions for the most rapid evolution is true or not, selection itself will create genetic diversity in the local populations of different habitats or micro-habitats. Genetic 'drift' arising from statistical sampling accidents can have little power to alter the outcome of these strong selective processes.

A second point is that in a region of great ecological change we can expect simultaneous clinal variation in the frequencies of genes at a number of loci. Variability under the control of selection along an ecological gradient may reach a peak and decay on both sides of this peak. This situation would lead to the 'loose association of variables' which Anderson[10] considers to be diagnostic of the 'introgression' of the germ plasm of one species into another by hybridization and repeated back-crossing. If the environmental factors which are significant in selection vary mosaically, a complex pattern of interlocking clines could be built up by selection alone. It would be difficult if not impossible to decide whether 'introgression' or selection had built up the 'loose association of variables' without the experimental measurement of selective coefficients. In none of the numerous cases now interpreted by introgression has this been attempted. It is probable that the data from such studies would often be better handled by the methods of clinal analysis, for example, Woodson's or Hall's descriptions of variation in *Asclepias* and *Juniperus*, where the clines cover hundreds of miles, or Anderson's descriptions of *Oxytropis*, where the clines occur over a few hundred feet of altitude.

It is, perhaps, worth considering a little further other general reasons for the popularity of 'introgression'. They are two-fold. The first is the idea that speciation always depends on a prior geographical separation of two or more populations. This view has been strongly advocated by Mayr[11]. A necessary corollary of this view is that, where intergrading populations occur at the junction of two geographical subspecies or species, hybridization has occurred. However, with the demonstration that the selective coefficients of a gene may change from lethality to essentiality for survival within the free path of a pollen grain, Mayr's arguments may require re-examination. If our interpretation of the eucalypt clines is justified, it means that the green populations at the lower altitude limit are suffering a net reproductive loss of 5–10 per cent through the immigration of pollen-grains carrying genes producing glaucousness. The glaucous populations have a similar net reproductive loss through immigration of pollen grains from the green populations. With these intense selective forces, it is possible to imagine, in a cline of long evolutionary standing, mechanisms which prevent these reproductive losses being gradually built up by natural selection. The easiest method would be the adoption of a system of inbreeding. Hence, perhaps, the origin of so many of the self-fertilizing plant species. But slight differences in reproductive physiology could be selected which still preserve outbreeding in the sub-populations while increasingly preventing crossing between them. Mayr's arguments fail because he has not envisaged contiguous populations in one of which a gene may be lethal but in the other essential to survival. Under this umbrella of intense selection, correlated adaptive changes in gene frequency must gradually build up, thus increasing the chances of the origin of a genetic sterility barrier leading to a simultaneous increase in the adaptive value of both populations.

The second reason for the popularity of introgression arises from the nature of the changes in phenotype so often seen in clines or 'hybrid swarms'. The segregating differences seem so trivial—small changes in habit, in shape and colour of flower or fruit or leaves, etc. If we adopt an explanation based on 'introgression' the problem of the function of the segregating differences in phenotype can be forgotten. If, as we believe, it is possible to design experiments to show that many of these apparent 'introgressive' phenomena are the consequences of intense selection, the problem of function of gene and character is thrust upon us. Too much of our thinking on these problems of function is still dominated by the anti-Darwinian speculations of fifty years ago.

Let us conclude by returning to a consideration of the function of the main clinally varying characteristic in the populations of *Eucalyptus urnigera*. It is possible that the layer of wax is functionless, the cline being selected on the basis of some pleiotropic gene-action. This is unlikely on general grounds[12] and it seems unlikely to be the case when several species show parallel clines and also when there is such an accurate correlation of intensity and pattern of wax deposition with ecology. What advantages or disadvantages can possession of a waxy layer over leaf and stem give to a seedling or adult tree? The possibilities are legion. They include: (1) protection from too great a cuticular transpiration, particularly in young expanding leaves when the epidermal coverings cannot be fully developed; (2) protection from too intense insolation; (3) alteration of the surface properties of the leaf. The glaucous leaves shed water rapidly, while green leaves may carry a persistent film of water. Has this alteration in surface properties any significance from the point of view of frost injury, (4) insect attack, or even (5) collection of water from fog and mist? These are, of course, the sort of questions it was fashionable to ask in the heyday of Darwinism. Then it was impossible to design experiments to answer such questions and consequently consideration of such problems has become unfashionable. However, the progeny of a tree heterozygous for genes controlling a clinally varying characteristic seems an admirable population for experiments designed to answer such questions on function of substance and structure. It is hoped to use some of the progenies for experiments of this nature and thus attempt to close one of the great gaps in evolutionary theory. Genetics has rewritten Darwin's theory of natural selection. This genetical theory of natural selection must now be used for interpreting in physiological and ecological terms the adaptive values of gene substitutions.

We wish to thank Miss M. Szokoloczi for help in scoring the progenies.

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GROWTH AND THE BREAKING STRAINS OF CERTAIN NEEDLE CRYSTALS

By J. E. GORDON

Tube Investments Research Laboratories, Hinxton Hall, Cambridge

HYDROQUINONE, quinone, resorcinol, $MgSO_4.7H_2O$, $NiSO_4.7H_2O$ and $ZnSO_4.7H_2O$ form long needle crystals which, in the macroscopic form, are always sensibly straight and are also very weak mechanically. Hexachlorbenzene (C_6Cl_6) forms long needles which are sometimes straight and sometimes curved. Observations were made of the growth of crystals of these substances under conditions of fairly rapid crystallization and especially under mechanical strain, from the point of view not of a crystallographer, but of a structural engineer. In general, hydroquinone and quinone were crystallized from water, resorcinol from water and from benzene and hexachlorbenzene from benzene and from chloroform. The three sulphates were crystallized by adding ethyl alcohol to their aqueous solutions.

The most numerous observations were made upon hydroquinone. The growth of needle crystals of the α-form (hexagonal) can be watched when a drop of the aqueous solution is allowed to evaporate upon a microscope slide in a warm room. If evaporation is too slow, the crystals may be predominantly γ-hydroquinone (monoclinic), which is of no interest for the present purpose.

While there appears to be more than one mechanism by which such crystals can grow, that which will be described is often observed both in hydroquinone and in the other substances examined, with the exception of hexachlorbenzene.

The first evidence of crystallization is frequently the appearance of very fine filaments which are barely visible under the optical microscope and which spread very rapidly through the liquid in many directions. Both the frequency and the straightness of such filaments (which have perhaps a thickness of between 0·1 and 1·0μ, being somewhat variable) seem to depend both upon the temperature and upon the supersaturation of the solution. When crystallization is slow and the solution is cool, the filaments are few and straight; if crystallization be rapid and if the solution be warmed a few degrees above room temperature, a mass of curved filaments resembling cotton wool is observed. In both cases individual filaments are often of great length, sometimes extending to a centimetre or so.

In the next stage the thin filaments thicken by the spread of growth-layers which have often visible steps and which frequently, though not always, encircle the filament after the manner of a tube. Upon the whole, the straighter filaments thicken the more quickly; but if crystallization is rapid, all the filaments, both bent and straight, will thicken. This stage of the process, for hydroquinone, is shown very clearly in Fig. 1, in which four crystals are shown in the process of thickening. In one of these the growth layer is too thin to be resolved in the photograph, in the other three the growth-layers are 5–10μ thick.

As the bent crystals become thicker, they tend to straighten, and if they are prevented from doing so they can be seen to exert relatively considerable

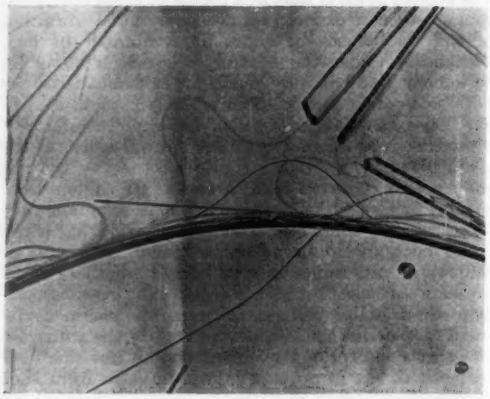

Fig. 1. Four curved primary filaments of hydroquinone being straightened by secondary growth layers of various thicknesses. × 100. (Photograph by R. W. Gooding)

forces upon the obstructions. Frequently the bent crystal succeeds in freeing itself and in springing straight; in Fig. 2 a hydroquinone crystal has been photographed just as it straightens itself.

If, however, a bent crystal is unable to free itself and if it goes on growing, it will eventually break as a beam in bending and the two broken parts will spring straight. In Fig. 3 a highly bent hydroquinone crystal can be seen near the centre of the picture with a growth step just visible near the point of maximum curvature. This crystal was growing rapidly when the photograph was taken and broke a moment afterwards.

In many hundreds of observations with hydroquinone, only one reliable example of a 'permanent

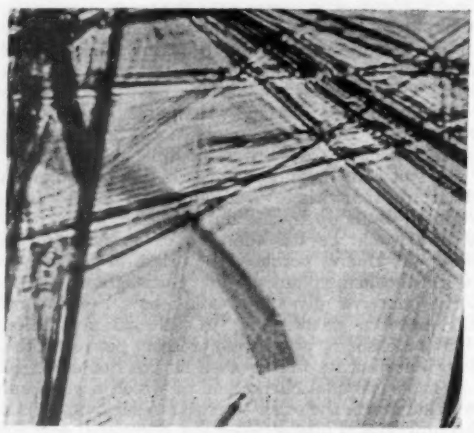

Fig. 2. A hydroquinone crystal, grown bent, has freed itself and is in the act of springing straight. × 560

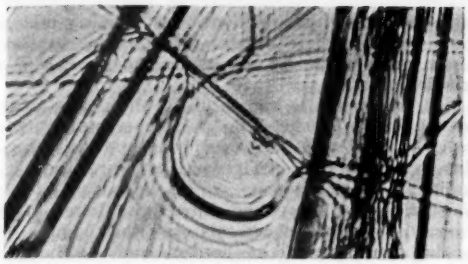

Fig. 3. A bent hydroquinone filament is thickening rapidly and is about to break. Note growth step. After fracture the crystal became quite straight. Approximate strain at failure 6–8 per cent. × 400

set' has yet been observed. Although more or less bent crystals are frequently seen when hydroquinone solution is evaporated on glass, when the adhesion to the glass is released (for example, by washing the crystals off with paraffin), they will always become sensibly straight. The strains observed in the crystals, even up to mechanical failure, are therefore elastic and can be estimated from the geometry of the curved crystals. If we assume equal Young's moduli in tension and in compression the maximum tensile and compressive strains will both be $\epsilon = t/2R$, where t is crystal thickness and R is mean radius of curvature.

R can be assessed with fair accuracy; t is subject to the usual errors which accompany the observation of thin filaments in the optical microscope but has been checked in a few cases by an interference method. In the case of thin crystals, the strains reported are therefore approximate. (It is hoped to extend this work with the X-ray microscope.)

Although fewer observations were made upon quinone, resorcinol, and magnesium, nickel and zinc sulphates, complete elastic recovery of crystals grown under strain is almost certainly the case; and it is also probably true of urea, phenol and potassium permanganate (which are less convenient substances with which to work).

It is possible to grow curved crystals of nearly all these substances until fracture occurs, and the method in fact constitutes a practical and fairly convenient technique for assessing the breaking strains. With fine needle crystals, two to four microns thick, the breaking strains observed were high, and at least of the order associated with the strongest metal whiskers[1]. In the case of hydroquinone, normally a very weak substance, breaking strains in the range of 6–8 per cent were frequently measured. Since growth occurs by the spread of sharp-fronted growth terraces (electron microscope photographs by J. W. Menter[2] indicate that growth-steps in phthalocyanine crystals may be sharp to a radius of a few molecules) and since the strains have been shown to be fully elastic, there must exist severe concentrations of stress at the growth-terrace re-entrant. As a result, the strains estimated from simple beam theory must be multiplied by a factor of from three to five and perhaps more at the point of growth. In other words, these crystals can grow in an apparently normal manner while subjected to strains in the region of 20–40 per cent. Although such strains are probably comparable with those associated with single edge dislocations, and although it would seem that the growth layer when spreading in the strained substrate has a strong inducement to form edge dislocations, in fact in the crystals described the formation of edge dislocations must be very rare, judging by the complete elastic recovery. Thus, for the crystals described, mechanical strain during growth is not an important factor in the formation of edge dislocations, and it is quite possible and indeed normal for sensibly perfect crystal layers to be laid down at what seem to be enormous strains.

Such behaviour is not, however, universal, since hexachlorbenzene, which forms needle crystals by the thickening of filaments in a very similar manner to hydroquinone, behaves differently when grown under strain. When grown under strains up to roughly 0·5 per cent, the behaviour is in all respects similar to, say, hydroquinone. However, a curved crystal allowed to thicken to such an extent as to exceed this strain loses most of its power of recovery and must presumably grow with edge dislocations. It is therefore impossible to use the method of growing curved crystals to measure the breaking strain of hexachlorbenzene. When manipulated under the microscope, such crystals can be bent in a ductile manner and seem to have slip planes parallel to the length of the needle.

For all the crystals described, other than hexachlorbenzene, it seems probable that the needles formed in the early stages of crystallization, which behave fully elastically up to very high strains, are sensibly perfect crystals analogous to metal whiskers. However, whereas whiskers seem to be a comparatively rare form of metallic crystal produced only under rather special conditions, sensibly perfect crystals seem to be a normal, and perhaps an essential, stage in the growth of the crystals described. As to whether these needles grow by a screw dislocation mechanism, there is at present no reliable information.

Additional evidence for the perfection of these thin crystals is that bent and highly strained needles of hydroquinone can be kept in air at room temperature for several months without deterioration, in spite of the fact that hydroquinone has an appreciable vapour pressure and will generally sublime at room temperature.

Although high breaking strength is generally retained up to crystal diameters in the region of five microns, above this thickness the crystals are weaker, generally falling off to a negligible strength at about 100 microns. Occasionally, growing needles of 30–50

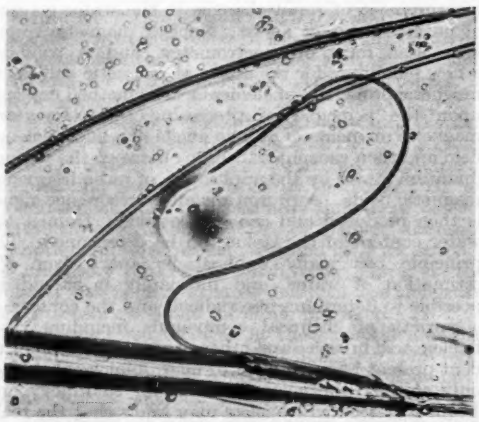

Fig. 4. Hydroquinone crystal about 2μ thick grown straight and afterwards bent mechanically to about 5 per cent strain. × 200

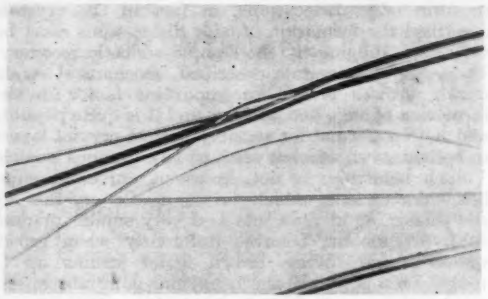

Fig. 5. Forking and interpenetration of hydroquinone crystal. × 130. (Photograph by R. W. Gooding)

microns thick have been observed to break spontaneously under no bending strain, an effect presumably produced by high internal stress.

High strength is not of course confined exclusively to crystals which have been grown in the bent state. Fig. 4 shows a hydroquinone crystal a few microns thick grown straight and afterwards bent to about 5 per cent strain by mechanical manipulation in petroleum jelly.

Not very much is known about the nature of the defects which weaken the thicker crystals. Since these crystals can be grown bent and will almost always become fully straightened when released, it is unlikely that the defects are of the nature of edge dislocations. Films which have been taken of the growth of the thicker crystals show that complicated forking and rejoining mechanisms such as that seen in Fig. 5 undoubtedly occur, but it is doubtful if these account for all the facts. It is not easy to postulate a growth mechanism by which substantial defects can be introduced without at the same time introducing the probability of a relief of strain energy which would result in a 'permanent set' in crystals grown while bent.

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SUB-MICROSCOPIC ORGANIZATION AND FUNCTION OF NERVE CELLS

AN international symposium on "The Fine Structure of the Nervous System" was held in the Venezuelan Institute for Neurology and Brain Research during March, under the auspices of the International Society for Cell Biology. The proceedings will be published as a supplement to *Experimental Cell Research*. The papers were drawn from the fields of electro-physiology, electron microscopy, chemistry and histochemistry. Spectroscopy and flame photometry also figured in the programme. Inspection of the Institute during the Symposium showed it to be the best equipped in the world for the application of physical techniques to the study of biological problems. Probably the most intriguing new technique demonstrated was that of nuclear magnetic resonance and its application to the measurement of rapid changes in the water content of untreated intact nerve. Nuclear magnetic resonance is a form of spectrometry, and it provides a new technique for the study of magnetic and paramagnetic properties of elements. The method depends upon the principle of precessing the elementary magnetic moments of atomic nuclei in a homogeneous field and then causing transitions between the various quantum states by the application of radio-frequency magnetic fields. A proton magnetic resonance signal is then produced and can be recorded: from it the water content of the tissue can be determined. The principle has many applications apart from the estimation of water, and ultimately it should be possible to determine free radicals and the content of a variety of chemical compounds including ribonucleic acid in nerve and other tissues. This technique is at present being applied to neuro-biological studies only at the Venezuelan Institute for Neurology and Brain Research. Physicists may know that the technique of nuclear magnetic resonance is to be used, in conjunction with the Earth satellite to be released later in the year, to measure the Earth's magnetic field at great altitudes.

The papers at the symposium fell into four groups: on the nerve fibres, the nerve cell membrane, the neuron, and the receptors. The papers presented in the first of these groups centred around the theme of axon–satellite cell relationships, and this naturally included the structure of the myelin sheath. Dr. Herbert Gasser was concerned particularly with the structure of unmedullated nerves. He established as a general principle that non-medullated fibres run in, and are supported by, the Schwann sheaths of medullated fibres in mixed nerves. Dr. Gasser pointed out that the sustentacular cells and basal cells of the olfactory mucosa behave like Schwann cells in this aspect, and he demonstrated a very intimate relation between the basal cells and the axon of the olfactory cell passing between them. This led naturally to the consideration of the relationship between satellite cells and the myelin sheath of medullated nerves. Dr. F. O. Schmitt dealt with the recent suggestion, based on experimental observations on neurogenesis in tissue culture, that the satellite cell wraps in spiral fashion around the axon, thus producing alternate layers of phospholipid and protein (the jelly-roll theory); and Dr. Fernandez Moran's beautiful high-resolution electron micrographs demonstrated that the laminæ of the myelin sheath which he had previously described could indeed be traced in a spiral pattern. Dr. Moran also demonstrated that if nerve is centrifuged at 200,000 *g* for twenty-four hours with its axis radially arranged, the axonal material is centrifuged into a drop. By this means pure axon material can be obtained for investigation. Under such treatments the lamination of the myelin sheaths is well preserved. The myelin sheath was the subject of X-ray diffraction studies by Dr. J. B. Finean, and he showed that a distinction must be made between myelin of peri-

pheral nerves and myelin of central origin. He also demonstrated differences due to dehydration and embedding with methacrylate as compared with gelatin.

Prof. A. von Muralt showed that during excitation of nerve, bound thiamine is liberated as free thiamine and that this is split very rapidly into at least two substances, X_1 and X_2, which are resynthesized into thiamine during recovery if energy from glycolysis is available. These thiamine transitions are closely connected with the sodium transport system, and Dr. P. Mueller, by burning a stimulated nerve fibre in a flame photometer, demonstrated an appreciable gain in sodium, and that this was equal to the loss of potassium which also occurred. He found that 10 per cent of the potassium in nerve cannot be exchanged in this way. It is of interest that Dr. Lorente de Nó found that sodium ions are not necessary in the external medium of nerve fibres for the conduction of action potentials, but that on the other hand the action potential is directly related to the amount of sodium inside the nerve fibre. He also demonstrated that a number of onium ions can be substituted for sodium and can restore the ability to conduct impulses in the sodium-deficient frog. His results indicate that local anæsthesia is due to competitive inhibitions of chemical reactions which require the presence of sodium inside the nerve fibre.

Dr. C. G. Bernhard showed in model experiments with cats and monkeys that corresponding doses of local anæsthetics selectively block the ephaptic type of neuron interaction, and that small intravenous doses of local anæsthetics thus reduce the ephaptic motorsensory fibre transmission at the injured region of peripheral nerve. Dr. J. Folch Pi directed attention to the fact that nervous tissue contains ionic lipids, for example, phosphatidyl serine, diphosphine inositide and cerebron sulphuric acid. Whether such lipids are related to the ionic balance in nervous tissue has yet to be discovered.

Dr. G. H. Bourne pointed out that a number of phosphatases are concentrated along the membranes of the dendrites of the pyramidal cells in the cerebral cortex and that these and other cells and their processes appear to be embedded in phosphatase-rich tissue. Attention was also directed to the fact that the basal cells of the olfactory epithelium, with which the axons of the olfactory cells enter into intimate contact, show extremely high phosphatase activity. In a review of modern theories of ion transport in membranes, Dr. T. Teorell suggested that the mutual action of electrochemical and hydrostatic 'pressure' differences might lead to oscillatory membrane phenomena revealed by periodic variations in membrane potential, membrane conductance and pressure difference.

From cell processes interest then turned to the neurone itself, and Prof. R. Jung showed how extracellular recordings of single-neuron discharges from the visual cortex in the cat 'encephale isolé' preparation were used for investigating the co-ordination of the cortical neuronal system. He found that the neurons of the visual cortex show a well co-ordinated pattern following light stimuli and a tendency to restrain excitation. He concluded that this neuronal system tends to maintain a medium level of activity and an adequate regulation of cortical function corresponding to an actual situation by four self-regulating control mechanisms. This was followed by Dr. D. P. L. Lloyd's paper on "The Approach of Unitary Analysis to Neuron Response". He described how as each motoneuron encountered is examined, it is characterized according to the number of responses in a set number of trials at afferent stimulation fixed in frequency and intensity. This assemblage of units represents a synthetic motoneuron pool and the sum of their individual behaviours can be compared in a given situation with that of a natural pool. This synthetic pool can be utilized to provide information that cannot be extracted from a study of natural pool responses. Such a study of individuals suggests that details of heterosynaptic organization, rather than wide variation of motoneuron threshold, underlies heteronymous transmission during the peak of post-tetanic potentiation, and that low-frequency depression is due to action upon the motoneurons rather than to a reduction in presynaptic efficacy. Dr. Lloyd directed attention to the fact that the introduction of the intracellular microelectrode technique for representative sampling of motoneurons would appear to merit the most careful attention. His paper was therefore very appropriately followed by Dr. G. Svaetichin's paper on action potential analyses and electrical stimulation of single neurons, in which he demonstrated that when an electrical stimulation was applied on to the perikaryon of a dorsal root ganglion cell, either extra- or intracellularly, the action potential always started at the *M*-region of the axon, and he suggested that in synaptic activation the electrical response also starts in the same *M*-trigger region. Further papers on the neuron dealt with its chemistry and its fine structure as seen with the electron microscope. Dr. H. Hydén described methods in use in his laboratory for the localization and quantitative determination of ribonucleic acid nucleotides, lipids and protein in nerve cells. Dr. V. L. Van Breemen described the presence of small vesicles in the axon, visible under the electron microscope, and found that these and other constituents undergo similar changes in both neuron and axon following ligation of the axons or injection of malanonitryl. Dr. Fernández Morán demonstrated the characteristic association of membrane profiles with the dense granular material of the nerve cell body, the presence of filament-like structures in the cytoplasm, the fine structure of the nucleolus and pores in the nuclear membrane 700–800 A. across. Dr. J. L. Luft showed a system of 'electroplaques' in the electric tissue of fishes which contain a highly developed system of tubules and vesicles extending from the plasma membrane into the interior of the plaque. This system could be associated with one phase of ion transport occurring by vesicular transfer, in a manner analogous to that proposed for the function of synaptic vesicles in nerve endings.

These synaptic vesicles were beautifully demonstrated by Dr. E. de Robertis and Dr. S. L. Palay in their respective papers; and also in adrenal medulla and neurohypophysis by the latter. Dr. de Robertis dealt with the possibility that these vesicles contained acetylcholine. Dr. S. Kuffler discussed synaptic inhibitory mechanisms and gave an analysis of inhibitory processes which took place at the isolated two-neuron synapse between the dendrites of the sensory cell and an inhibitory axon. Prof. G. Causey described changes in the synaptic areas in the superior cervical ganglion following pre- and post-ganglionic section, and Prof. T. H. Bulloch gave an account of synaptic and intra-neural parametery of integration in some invertebrate ganglion cells. Dr. R. Couteaux demonstrated the localization of acetylcholine in motor end plates.

The final section of the conference dealt with the receptors. Dr. Fernandez Moran described the structure of the insect retina, which is of particular interest in view of the ability of insects to orient themselves by polarized light. Dr. George Wald summarized the relation of visual pigments to the process of vision, and Dr. G. Svaetichin gave an analysis of the receptor potentials from single cones. Dr. E. F. MacNicholl gave an account of the subliminal slow potentials recorded from the eye of *Limulus*, and Dr. H. Autrum an electrophysiological analysis of the visual systems of insects. Drs. Forbes and Deane presented electrical studies of colour vision in the turtle. The physiology of olfactory, sound and taste receptors was described by Drs. D. Ottoson, H. Engstrom and Y. Zotterman. Drs. K. Porter and G. Palade discussed membrane-limited systems, in particular the endoplasmic reticulum in the cytoplasm, and paid special attention to its manifestations in striated muscle, where it was suggested it may play a part in transmitting depolarization from the sarcolemma to the myofibrils.

Membrane resting potential of muscle was considered by Dr. J. W. Woodbury, the morphology of muscle fibres with different conducting properties by Dr. H. Ruska and ciliary co-ordination in Protozoa by Dr. L. E. Roth. Dr. L. U. C. Junquiera gave a statistical account of the number of nerve cells and ganglia in the different parts of the intestinal plexuses, and Prof. J. Runnstrøm analysed the cytoplasmic changes occurring upon fertilization in the sea urchin egg.

It is obvious that a wide field was covered, and all taking part were agreed that the symposium was a considerable success. On the Saturday following the conclusion of the symposium, the President of Venezuela visited the Institute, met the participants and spent most of the morning talking with them. There is no doubt that the Venezuelan Institute for Neurology and Brain Research has been scientifically launched and that it is embarking upon a series of fundamental investigations on the nervous system which cannot fail to make it the outstanding Institute of its kind in the world. Geoffrey H. Bourne

CYTO-TAXONOMY

THE Linnean Society of London held a whole-day session on cyto-taxonomy on May 3. Dr. W. B. Turrill introduced the symposium. He pointed out that the study of chromosomes was only one branch of cytology, and expressed a hope that cell contents other than the nucleus would receive due consideration. There is no doubt that cytological data can often be used by the taxonomist, but they have to be correlated with characters from many other branches of botany and zoology and taxonomically evaluated in connexion with these. Insufficient numbers of species have so far been adequately studied cytologically, especially in tropical and subtropical floras, for wide taxonomic generalizations validly to be made on the basis of cytology. Many taxonomists are whole-heartedly in favour of synthetic taxonomy and welcome any contribution that cytologists can make towards elucidating the problems of taxonomy. The number of biologists who regard cytologists as queer and perverse ultra-modernists who "peer down a microscope and count their own eye-lashes" is dwindling. They are, however, irritated by those cytologists who, from ignorance, scorn the basic work of taxonomists and appear to believe that scoring the chromosomes tells one everything one needs to know about a plant. Exaggerated claims or extreme criticisms made by taxonomists or by cytologists are to be deplored. What is needed is co-operation based on an understanding of each other's aims and methods and expressed in attempts to synthesize results.

Mr. J. L. Hamerton, in his paper, "Problems in Mammalian Cytotaxonomy", began by reviewing the advances in technical methods which had occurred during the past ten years and which had led to the development of modern techniques for the study of mammalian chromosomes, so that rapid and accurate chromosome counts, and detailed studies on chromosome morphology were now possible. It was emphasized that for comparative work counts of chromosome number alone were not sufficient and that studies should embrace all aspects of chromosome morphology.

The concept that the chromosome number must necessarily be constant throughout the range of a morphological species was discussed and rejected, and it was pointed out that it was the population which was of major importance in cytogenetical work rather than the morphological species.

The relative importance of aneuploidy, polyploidy and structural change was considered in respect of mammalian evolution, and it was emphasized that there was not necessarily any direct relationship between chromosomal and morphological change, though there are certain obvious exceptions to this. Mr. Hamerton considered that the main result of chromosomal change was the introduction of discontinuity leading to some degree of isolation or variation which in turn might lead to eventual phenotypic differences of a specific nature.

The results of chromosomal change in mammalian evolution were considered at both the inter-specific and intra-specific levels. Data on experimental polyploidy in the mouse were reviewed briefly, and the evidence for polyploid evolution in the hamsters was discussed. It was considered that insufficient evidence was available to determine whether polyploid evolution had occurred here or not. Further detailed morphological studies on the chromosomes were required, and some attempt should be made to produce hybrids and back-crosses, perhaps by artificial insemination, for subsequent cytological analysis.

Chromosomal polymorphism and the existence of chromosome races or cryptic species in mammals was discussed, and their evolutionary significance considered.

Dr. A. J. Cain stated that although there is general agreement that chromosomes are important in taxonomy there has been little analysis of what is meant by taxonomic importance. The study of chromosomes can contribute three main classes of

data, namely, substitute breeding data, comparative data, and substitute phyletic data. These classes must not be confused and the possibilities of convergence and mistaken homology must be remembered. Illustrative examples were provided by researches on earthworms.

Dr. M. Fischberg dealt with the effects of outcrossing on the chromosome number in vertebrates. Chromosome differences may change the physiology enormously. In mice heteroploid embryos occurred if individuals from different inbred lines were crossed. In Amphibia the percentage of young with abnormal chromosome number increased with increasing genetical variation of their parents. If polyploids are produced and if they hybridize with diploids an explosion-like variation of genotypes may result. Even if there be a very high mortality of the variants some may survive and start new evolutionary lines.

Prof. Irene Manton gave an extensive outline account of the chromosomes and classification in ferns. Some ten to fifteen thousand species of ferns are known taxonomically and are classified into about three hundred genera. Prof. Manton had examined cytologically about five hundred species belonging to approximately a hundred genera. The majority of the species are tropical. Chromosome numbers can be accurately counted, and it has been found that with few exceptions the species within a genus have the same basic number. The exceptions may be due to mistakes in taxonomy or to shifts in one chromosome. The classification proposed by Copeland was subject to criticism especially in the Pteridaceae and Aspidiaceae. There is no doubt that the study of chromosomes can lead to improvements in classification in the ferns.

Dr. T. G. Walker considered in some detail the cyto-taxonomy of a tropical fern complex (the *Pteris quadriaurita* complex). The large complex of ferns centred around *Pteris quadriaurita* Retz. has been the source of much taxonomic confusion. Many members of the complex have been made the subject of a cyto-taxonomic and genetical investigation and some of the results for the Ceylon members were reported. It has been found that there are in Ceylon several species which, although possessing a similar gross morphology, are cytologically distinct and remain distinct as species under natural conditions. Such species can, however, be recognized by several relatively small morphological characters, the diagnostic importance of which has been overlooked in the past.

Two species were then discussed which contrasted strikingly with the other Ceylon members of the complex. These two species in gross morphology are very different from one another (but cytologically similar) and in Nature frequently meet to produce fully fertile hybrids. Such hybrids segregate into a wide range of morphologically different but not true-breeding individuals, several of which in the past have been described as new species by herbarium botanists. Observations made in the field in Ceylon relevant to the ecology of these species and their hybrid swarms were also reported.

Dr. A. B. Acton pointed out that the minute differences that accumulate in animals which are destined to become specifically distinct may be indistinguishable from uninherited, and consequently less important, variations. The banding-patterns of giant chromosomes are an exception. The chromosomes of *Chironomus tentans* larvæ in a single population differ from each other by inversions. The chromosomes of larvæ in nearby populations contain, as a rule, exactly the same inversions, but at different frequencies. This is true of populations as far apart as Sweden, Austria, and Britain.

The chromosome banding-patterns in *C. tentans* larvæ from Canada differ from those in Europe. Not only do some of the inversions by which the chromosomes of European and Canadian larvæ differ occur as heterozygotes (in Europe), but there are certain inversion heterozygotes which are found in both areas. There are no external differences between either larvæ or imagines; hybrids can be made and these appear to be perfectly viable. The situation is intermediate between the one found to exist between individuals of a single species and those of two distinct species. Even though it is possible to detect minute differences between the giant chromosomes of different larvæ, it may still be no easier to decide the taxonomic status of the animals concerned, and it will continue to be necessary to appeal to the 'competent taxonomist'.

Prof. D. H. Valentine outlined the cyto-taxonomy of the rostrate violets. The Rostratae form a sub-section (comprising thirty-five species) of the very large section *Nomimium* of the genus *Viola*. Taxonomically they are well defined by their possession of overground leafy stems and by the hooked beak to their style; the basic chromosome number is 10. All species of the sub-section so far tested (fourteen) form viable hybrids with one another and it might be thought that the group constituted a comparium; but, as shown by Gershoy, artificial hybrids with the sub-sections Stolonosae ($n = 12$) and Borealii-Americanae ($n = 27$) are possible, and wild hybrids with the Uncinatae and the Repentes (both with $n = 10$) have been recorded. Thus the comparium extends beyond the bounds of a single sub-section.

The relationship of the species within the Rostratae may be tested by crossability and by cytological analysis. The group was divided by Becker into the Mirabiles (two species), the Arosulatae (nine species), and the Rosulantes (twenty-two species). The last are generally chamæphytes with a basal leaf rosette, and the Arosulatae, hemicryptophytes without a rosette. Hybridization experiments show that viable interspecific hybrids are produced just as easily between these groups as within them, and there are no significant differences in the fertility of the hybrids, which is always low. Chromosome counts (by various authors) have shown that, of the species investigated (fifteen), ten are diploid. There are three tetraploids and a hexaploid in Europe and one octoploid is reported from North America; no linking species between this octoploid (*V. howellii*) and the remaining North American species, which are diploid, are yet known.

Studies of chromosome pairing in interspecific hybrids between the European species indicates that two (the rosulate *V. riviniana* and the arosulate *V. canina*) are amphiploids and that they have one genome in common. Whether there are further chromosome homologies between members of the rosulate and arosulate groups is not yet known.

The Rosulantes have a circumpolar distribution, while the remainder of the group is Eurasiatic. Comparison of the morphology, distribution, and cytology of the North American and Eurasiatic species of the Rosulantes may make it possible to work out their evolutionary history and thus to make a contribution to our knowledge of the history and migrations of Tertiary floras. W. B. Turrill

OBITUARIES

Prof. Pierre Bugnon

Pierre Frédéric Bugnon was born on January 14, 1886, and died on May 11, 1957. After holding academic posts at Caen and Rennes, he was, until his retirement, professor of botany at Dijon. In his student days he worked at botany, zoology and geology at the Universities of Caen and Lyons. In 1910 and 1911 he was Octave Lignier's pupil, and he later became his colleague at Caen. Lignier's mind had more than a touch of genius, and his intellect and insight were the determining factors in the primary orientation of Bugnon's researches. Lignier recommended him to make himself proficient in the morphology and anatomy of modern plants before turning to the problems of fossil botany, and it was, in the end, the structure and phylogeny of the plants of to-day to which Bugnon gave his allegiance, though he retained his interest in palæobotany.

Bugnon obtained his Paris doctorate in 1921 for a thesis on the leaf in the Gramineae, in which he gave special attention to the phylogenetic evidence derived from the peculiar seedling structure of this group. He developed different aspects of his thesis in the succeeding years, his memoir on the ontogeny of the conducting system in the Gramineae being specially notable. Eventually his work branched out from these and related topics to studies of many other problems arising out of the morphology of the flowering plants. In a brief note such as this, no adequate idea can be given of the scope and variety of his own large output, or of the work of the research students whom he directed and inspired. He often dealt, lucidly and incisively, with controversial questions; even when one disagreed with his interpretations, his memoirs were always found to be thoughtful and thought-provoking. He had the French capacity for absorption in the things of the mind, controlled always by a deep respect for the facts of experience. His standards were high, and he was entirely without pretension; he once said to me, "Je suis barbare, moi", but this description of himself was belied completely by his own sensitive verbal expression, and by his horror at those misuses of language in which quiet appropriateness is lost through over-emphasis.

Though they were merely side-issues among Bugnon's preoccupations, his enthusiastic contributions to the field botany of Normandy deserve mention. Late in August, 1927, my daughter and I spent an unforgettable day walking under his guidance in the region of the joint estuary of the Douve and the Vire to see the cord-grass fields. We were accompanied by Louis Corbière, who had detected *Spartina townsendii* here for the first time in 1906, when 15–20 tufts were observed in one place, and another small stand elsewhere. Twenty-one years later, when we saw it during this walk in the full beauty of its anthesis, it had succeeded in clothing some two thousand acres of what had formerly been sterile mud flats.

Pierre Bugnon's son, François, known for his work on morphology and anatomy, began his botanical career in his father's laboratory, and thus, indirectly, under Lignier's influence. A research tradition of quality and individuality, which might have been extinguished by Lignier's premature death, has thus been transmitted to further generations of botanists through Pierre and François Bugnon and their students.

Agnes Arber

Dr. H. R. Heath

Dr. H. R. Heath, head of the Physics Department of Battersea Polytechnic, died at the early age of forty-two on May 4, after a painful illness. Educated at Halesowen Grammar School, he proceeded to the University of Birmingham, took an honours degree in physics, and was later awarded the Ph.D. degree for his research work on diffusion.

Dr. Heath had been a member of the physics lecturing staff of Battersea Polytechnic since the autumn of 1939, except for a break of four years war service in the R.A.F. Soon after his return to teaching, he was appointed senior lecturer in physics, and four years later became head of the Department. In the comparatively short time that he was to hold this office, Dr. Heath had been concerned with the building expansion of the Physics Department and with the initiation of a number of fresh courses in preparation for the new diploma in technology. Although taking his full share in teaching and in university examining work, he was also very active in extending the research activities in his Department.

Most conscientious in everything he undertook and always deeply concerned with the well-being of his students, his passing is a tragic loss at a time when he had still so much to contribute. Dr. Heath leaves a widow and a fifteen-year old son.

R. W. B. Stephens

Sir William Beach Thomas, K.B.E.

Few writers on the English countryside knew their subject better than the late Sir William Beach Thomas, who died on May 12. An athlete in his younger days—he was president of the Oxford University Athletic Club—a sometime war correspondent of distinction and a man of many activities, it is nevertheless his writings on country-life and Nature that constitute his outstanding achievement. A regular contributor to the *Observer* and the *Spectator* over many years and the author of a number of books, his love of the 'coloured counties' blazes from every article and every volume. He was a naturalist in the tradition of Gilbert White and Lord Gray, with an intense love for, and an unappeasable interest in, the life of field and hedgerow, coppice, stream and hillside, to say nothing of village and farmstead.

The son of a country clergyman, educated at Shrewsbury and Oxford, he was both by origin and upbringing a countryman, an Englishman who let his love of the countryside flow down his pen and on to paper with a fluency and skill that few have equalled, even if it was not always easy to decipher his handwriting. His books are truly English and full of the sights and sounds, the scents and smells, that from dawn to dusk and from sundown to sunrise make our England.

Frances Pitt

NEWS and VIEWS

The Queen's Birthday Honours List

THE following names of scientific men and others associated with scientific work appear in the Queen's Birthday Honours List:

K.B.E.: Brigadier L. H. Harris, engineer-in-chief, Post Office.

Knights: Prof. Gordon Roy Cameron, professor of morbid anatomy, University College Hospital Medical School, University of London; Harry Campion, director, Central Statistical Office, Cabinet Office, London: Prof. Alister Clavering Hardy, Linacre professor of zoology and comparative anatomy, University of Oxford; Prof. George White Pickering, regius professor of medicine, University of Oxford.

C.B.: Dr. D. W. W. Henderson, director of the Microbiological Research Establishment, Ministry of Supply.

C.M.G.: R. O. Hennings, permanent secretary, Ministry of Agriculture, Kenya.

C.B.E.: Arthur Beggs, of Beaufort, Victoria, Australia, for services to agriculture; A. T. Black, director of electronic production (munitions), Ministry of Supply; (the late) Dr. Macalister Brew, education and training officer, National Association of Mixed Clubs and Girls' Clubs; Dr. D. P. Cuthbertson, director of the Rowett Research Institute, Bucksburn, Aberdeenshire; J. W. Edmondson, assistant secretary, Ministry of Agriculture, Fisheries and Food; Basil Gray, keeper of the Department of Oriental Antiquities, British Museum; Prof. E. L. Hirst, Forbes professor of organic chemistry in the University of Edinburgh; Dr. Donald Hunter, physician and director of research, Industrial Medicine Unit, London Hospital; J. A. McMillan, senior education and advisory officer, National Agricultural Advisory Service, Ministry of Agriculture, Fisheries and Food; Prof. J. L. M. Morrison, professor of mechanical engineering, University of Bristol; R. J. Noble, under-secretary and permanent head of the Department of Agriculture, New South Wales; Dr. H. W. Parker, keeper of zoology, British Museum (Natural History); Dr. J. G. Pearce, director of research, British Cast Iron Research Association; A. H. H. Ross, lately director of forestry for Scotland; D. Skilbeck, principal of Wye College, University of London; Dr. D. G. Sopwith, director of mechanical engineering research, Department of Scientific and Industrial Research; Dr. J. H. Watson, chemist and assayer, Royal Mint.

I.S.O.: Dr. J. Glasspoole, a principal scientific officer, Air Ministry; H. F. Hendry, a senior chief executive officer, Ministry of Agriculture, Fisheries and Food; F. W. Johnson, assistant director, R.A.F. Aircraft Research and Development Branch (Fighters) 1, Ministry of Supply; W. R. Kerr, deputy chief veterinary research officer, Ministry of Agriculture for Northern Ireland; D. W. La Mare, director of fisheries, Federation of Malaya and Singapore; W. B. Niven, a principal in the Department of Agriculture for Scotland; N. F. Wright, agricultural officer, Department of Agriculture, Fisheries and Forestry, Hong Kong.

University of Cape Town: Prof. J. P. Duminy

PROF. J. P. DUMINY has recently been appointed principal of the University of Cape Town in succession to the late Dr. T. B. Davie. Since the death of Dr. Davie in December 1955, Prof. R. W. James has been acting principal.

Jacobus Petrus Duminy was born at Bellville, near Cape Town, on December 16, 1897. He attended the South African College School and studied mathematics and physics at the South African College, obtaining the degree of B.A. as a medallist. In 1918 the South African College became the University of Cape Town and he obtained the M.A. of the new University in 1920. He was a Rhodes Scholar and graduated B.A. and B.Sc. at Oxford in 1923 with a thesis on "Continuity and Infinity in Modern Mathematics and Philosophy". He also studied at the Sorbonne. On returning to South Africa he lectured for a time in mathematics and astronomy at the old Transvaal University College, and in 1930 was appointed to the chair of mathematics at the University of Pretoria, where he was dean of the Faculty of Science during 1933–39. In 1942 he became principal of Pretoria Technical College, which he has guided most successfully.

Prof. Duminy has served on many Government commissions on university and educational matters and has a wide knowledge of university finance and its relations to the Government. He has been a member of the Council of the University of South Africa and of the Universities Advisory Committee. He was a member of the South African delegation to the Unesco conference in 1947. Prof. Duminy is also an all-round sportsman and has played Rugby football, cricket and tennis and taken part in athletics and rowing; he played cricket for South Africa against the M.C.C. in the 1927–28 tour.

Mathematical Statistics at Brown University: Prof. Ulf Grenander

DR. ULF GRENANDER, of the University of Stockholm, has been appointed to the newly established chair of mathematical statistics and probability at Brown University. A native of Vastervik, Sweden, Dr. Grenander received his early education there. He attended the Universities of Upsala and Stockholm, receiving his doctorate at the latter in 1950. He has since been a visiting professor at the University of Chicago and a visiting associate professor at the University of California. Returning to Sweden, he became *docent* at the University of Stockholm, where he has served as acting chairman of the Department of Mathematical Statistics, and has published papers dealing with various aspects of the subject. He will assume his post at Brown University on September 1.

Rutherford College of Technology, Newcastle upon Tyne

IN a written answer to a question in the House of Commons on June 4 regarding the establishment of a college of advanced technology in the north-east, Sir Edward Boyle, the Parliamentary Secretary to the Ministry of Education, said that the Northern Advisory Council for Further Education has recently submitted a report on the pattern of technical education in the north of England with particular reference to the establishment there of a college of advanced technology. The Minister of Education agrees with the unanimous recommendation of the Council that a college of advanced technology should be established in the northern region as soon as possible. The Council made no specific recommendation, and the Minister considers that no existing college is at present suit-

able for designation; but he has decided to request the Newcastle Local Education Authority to undertake the development necessary at the Rutherford College of Technology so that it may become in due course a college of advanced technology. The College is to take its place in a regional scheme in which the other colleges in the region, and in particular the Sunderland Technical College and the Constantine Technical College, Middlesbrough, will play their full part, and the Newcastle Local Education Authority is to be asked to review the government of the College to afford representation to other authorities in the region. The Sunderland Technical College is to continue as a regional college, to make its distinctive contribution to technical education in the region, and the Minister hopes that the Constantine Technical College will also develop into a regional college in the near future.

International Association for Psychopharmacology

At the International Symposium on Psychotropic Drugs, held in Milan in May, it was proposed that an International Association for Psychopharmacology should be formed. Preliminary discussions took place during the Symposium, at which an organizing committee was elected, and it was decided that a definitive meeting should be held in Zurich at the time of the Psychiatric Congress in September. In the meantime, a representative of each country undertook to get into contact with those who might be interested in the formation of such an association. Anyone who is interested, or who has definite views regarding the scope and limitations of the proposed association, is invited to write to Dr. P. B. Bradley, Medical School, Hospitals Centre, Birmingham 15.

Ciba Foundation: Report for 1956

The report for 1956 of the Ciba Foundation for the Promotion of International Co-operation in Medical and Chemical Research lists the chairmen, speakers and subjects at the ten discussion meetings held during the year. Six film sessions were also arranged. Five Foundation conferences, at which the invited audience, drawn from different countries, did not exceed thirty, were held, together with one guest symposium on "Anoxia", which represented a new departure. The eighth Ciba Foundation Lecture was given by Prof. R. B. Woodward, of Harvard University, on December 5, 1956, on "Recent Advances in the Chemistry of Natural Products". Seven British and six French candidates were selected for short-term bursaries under the Anglo-French exchange scheme, and four awards of £200–£400 and five grants of £100 were made in support of research relevant to the problems of ageing. Five volumes of the general symposia, one volume on the colloquia on endocrinology and one on the colloquia on ageing were published by J. and A. Churchill, Ltd., and in the United States the first seven of the Foundation's books were published by Blakiston Co., New York. Details of publications, as well as of library acquisitions during the year, are included in the report.

The British Library of Political and Economic Science

The annual report for 1955–56 of the British Library of Political and Economic Science, London (pp. 16), records the completion of various additions and alterations to the premises, including provision of a special reading room for the more convenient use of manuscripts and rare books. Inter-library loans declined noticeably, but the number of 7,110 photostat prints supplied was the highest since the service began. Readers' permits fell to 589 compared with 613 in 1954–55, the total including 460 complimentary permits for academic research, 22 fee-paying permits for commercial research and 107 for undergraduate students, permit holders from overseas numbering 155. The total number of volumes in the Library on July 31, 1956, is estimated at 371,106, or 1,022,000 individual items; and 5,574 periodical titles are currently received as gifts from governments, municipalities, institutions and societies. Expenditure on current serials was £6,224 and on current binding £4,779, while expenditure on treatises and their binding was £6,182. A list of publications by members of the Library staff is appended.

Synthetic Waxes in Museum Work

An important article by Dr. A. E. A. Werner, of the British Museum Research Laboratory, on the uses of synthetic waxes in conservation appeared in the *Museums Journal* for April. Many of these substances differ chemically from the natural waxes but possess the same range of physical properties—inertness to ageing and ability to form an effective moisture barrier. Some of the synthetic waxes also possess properties not normally found in the natural waxes. The first group includes microcrystalline waxes isolated as by-products from the refining of petroleum. They differ from paraffin wax in being plastic and may be obtained in a wide range of melting points. The second group, which includes polyethylene, are produced by the polymerization of ethylene. These waxes are white and translucent, with a high melting point, and are characterized by their hardness and toughness. Lastly, polyethyleneglycol waxes, known commercially as 'Carbowax'; waxes of this group dissolve freely in water and in many organic solvents. The article includes some practical details and references to literature.

Thomas Telford Bicentenary Exhibitions

An exhibition commemorating the bicentenary of the birth on August 9, 1757, of Thomas Telford is to be opened at the Institution of Civil Engineers, Great George Street, London, S.W.1, by the Minister of Power, Lord Mills, on July 22. The exhibition will be open free to the public between 10 a.m. and 8 p.m. daily, Saturdays and Sundays included, until August 10.

An exhibition is being held in the entrance hall of the Engineering Laboratory of the Department of Engineering, Trumpington Street, Cambridge, to celebrate the bi-centenary of the birth of Thomas Telford. The exhibits have been collected from a large number of sources and include letters and sketches in Telford's own hand and a number of other objects of historical interest, together with a very fine collection of photographs and line drawings. The latter are grouped in sections, illustrating Telford's work on masonry and iron bridges and his designs for bridges not actually built, each illustration being accompanied by an explanatory note. A series of eighteen photographs records the various stages in the reconstruction of the Menai Bridge between 1938 and 1941. Another section is devoted to his canals and aqueducts, with a brief description of the engineering difficulties met and overcome. An illustrated map pinpoints the exhibits and denotes those works which are still in use. A chronology

summarizes the most important achievement of this remarkable man, who was born in a shepherd's cottage on Eskdale, became the first president of the Institution of Civil Engineers and a Fellow of the Royal Society and was buried in Westminster Abbey. The exhibition will remain open to the public on weekdays between 9.30 a.m. and 5 p.m. (12.30 p.m. on Saturdays) until July 15, except for the period June 24–29. There is no charge for admission.

Archæology in South Africa

Once again the annual report of the Archæological Survey in South Africa, for the period April 1, 1954–March 31, 1955 (Union of South Africa: Department of Education, Arts and Science. Pp. 8. Pretoria: Government Printer, 1956), shows considerable activity. Not only has work continued in the Makapan valley, where so many of the recently discovered remains of ape-men have been found, but also in the Pietersburg district. A picture of the archæology of the Central Transvaal has now been built up. Further work at Mapungubwe has been undertaken, and archæological sites in the vicinity of Krausberg, Muden and Weenen visited, where new rock paintings were discovered. Two other publications of the South African Department of Education, Arts and Science report archæological investigations in East Griqualand and Mapungubwe. In East Griqualand, industries belonging to the Fauresmith culture (first intermediate), the Middle Stone Age—early and late, the Magosian culture (second intermediate) and the Later Stone Age have been found. In "A Preliminary Account of the Archæology of East Griqualand", by B. D. Malan (Archæological Series No. 8. Pp. 14+10 plates. Pretoria: Government Printer, 1955. 10*s*.) details of the finds at a number of sites are given, with some good illustrations.

The account of "The Glass Beads of Mapungubwe" will be among the last of the articles by the late Dr. C. Van Riet Lowe to be published (Archæological Series No. 9. Pp. 22. Pretoria: Government Printer, 1955. 18*s*.). Mapungubwe is a small, flat-topped, sandstone hill on the farm Greefswald in the northern Zoutpansberg district, and is situated on the south bank of the Limpopo River. Excavations have been in progress at the site since 1933 and much interesting material has been discovered. More than one people occupied the site at different times. Dating, in such circumstances, is always somewhat problematical. There are clearly connecting links with Zimbabwe, but Mapungubwe, especially in its later phases, can be much later in date, possibly even belonging to the seventeenth or early eighteenth centuries of our era. The account of the glass beads found adds much to our knowledge, and the inclusion of a plate in colour is very valuable. Beads are somewhat unsatisfactory objects for the archæologist to deal with. They have a great survival potentiality, and are therefore not very useful for accurate dating, and they may often have been transported from great distances. It seems possible that the East Indies were in early times a considerable source of beads which later found their way to East Africa, and thence into the interior of the continent.

Lundy Field Society

The tenth annual report of the Lundy Field Society contains a heartening record of progress both in the financial and scientific spheres which should encourage the Society in its future activities. Besides the usual bird list, the report contains an account by H. J. Boyd of the biology of guillemots and razorbills as shown by ringing observations on the island over the period 1947–56. The same author has examined records of the gull populations over the same ten-year period; these show a steady decline in the numbers of great and lesser blackbacks and wide fluctuation in the numbers of kittiwakes. Barbara Whitaker describes results obtained from shag ringing between 1948 and 1955 and analyses the weights and measurements of certain migrant species which were trapped on the island. A description of a prehistoric settlement at Garret's Combe is contributed by K. S. Gardner. Copies of the report may be obtained from the secretary, Prof. L. A. Harvey, of the University of Exeter, price 5*s*.

Photoperiodic Control of Cambial Activity

An investigation of the effect of photoperiodic conditions on cambial activity in seedlings of *Robinia pseudoacacia* by P. F. Wareing and D. L. Roberts (*New Phytol.*, 55, 356; 1956) has yielded some new and interesting facts. The seedlings were first exposed to short-day conditions in order to bring about the cessation of extension-growth. If such seedlings were continued under short-day conditions for several weeks, the cambium of the stem also ceased activity. On the other hand, if the seedlings were transferred to long-day conditions after extension-growth had stopped, cambial activity was maintained in approximately half the plants. The maintenance of cambial activity depends upon exposure of the leaves to long-day conditions. In bark-ringing experiments it was shown that the cambial stimulus, which apparently originates in the leaves, is transported in a basipetal direction in the stem. The maintenance of cambial activity under long-day conditions is not accompanied by any detectable bud-growth. The new wood formed under long-days after extension-growth has ceased is of the 'summer-wood' type. The vessels in such wood appear to arise from the region in which the leaf-traces join the main vascular system of the stem. These results suggest that a cambial stimulus may arise in the mature leaves under long-day conditions, and that meristematic activity at the shoot apices is not a necessary condition for cambial activity.

Zoological Nomenclature

The International Commission on Zoological Nomenclature gives notice that, as from December 28, 1957, it will start voting on the following cases involving the possible use of its plenary powers for the purposes specified against each entry. Full details of these cases were published on June 28 in the *Bulletin of Zoological Nomenclature* (13, Parts 6 and 7): (1) *musicus* Linnæus, 1758 (*Turdus*), suppression; *iliacus* Linnæus, 1758 (*Turdus*), validation of neotype for (Cl. Aves); (2) *Oebia* Hubner, [1825], and emend. *Oebia*, suppression (Cl. Insecta, Order Lepidoptera); (3) *Indiana* Matthew, 1902, designation of type species for (Cl. Crustacea, Order Ostracoda); (4) *Globigerinidae* Carpenter, Parker and Jones, 1862, to be given precedence over *Orbulinidae* Schultze, 1854 (Cl. Rhizopoda, Order Foraminifera); (5) *Labeceras* Spath, 1925, designation of type species for (Cl. Cephalopoda, Order Ammonoidea); (6) *Calycoceras* Hyatt, 1900, designation of type species for (Cl. Cephalopoda, Order Ammonoidea); (7) *Hoplitoplacenticeras*, validation of, as from Paulcke, 1906, with *Hoplites plasticus* Paulcke, 1906, as type species (Cl. Cephalopoda, Order Ammonoidea); (8) *Kotoceras*

Kobayashi, 1934 (Order Nautiloidea) and *Damesites* Matsumoto, 1942 (Order Ammonoidea), validation (Cl. Cephalopoda). Proposals are also made for the adoption of declarations: (1) clarifying (*a*) the provisions of the "Code of Ethics", (*b*) the procedure to be adopted when a specific name is published in an abbreviated form and (*c*) the status of names published in works written in Latin; (2) determining the gender to be attributed to generic names with the terminations '-ides', '-ites' and '-oides'. Comments should be sent as soon as possible in duplicate to Francis Hemming, Secretary to the Commission, 28 Park Village East, Regent's Park, London, N.W.1.

Physics of Non-Destructive Testing

Under the title "Physics of Non-Destructive Testing", Supplement No. 6 to the *British Journal of Applied Physics*, published recently by the Institute of Physics, contains a selection of papers chosen from those presented during the past year at meetings of the Non-Destructive Testing Group. The technology of non-destructive testing is usually regarded as being confined to the task of detecting defects in materials and components. The detection of defects, however, forms a relatively small part of the whole subject for, if the term 'non-destructive testing' is taken in its broadest sense, it includes every type of non-destructive measurement carried out on solids, liquids and gases, with the object of examining some aspect of their physical, chemical and even biological condition. Very little is to be found in Supplement No. 6 about the physical principles upon which present-day techniques for detecting defects are based. Indeed, the one discussion reported dealing with this aspect of the subject serves to show that, in the particular case of the penetrant method for flaw detection, practically nothing is understood about the mechanism involved when a fluid penetrates a crack. The supplement records some of the current scientific investigations which are likely to yield the kind of knowledge required for the development of new types of testing technique. The information reported directs attention to the scientific background from which automatic systems of quality control will be created. There are papers dealing with the relationship between the structure of materials and their physical properties. Some papers are concerned with the measurement of those physical properties which would serve to detect changes in structure and composition of materials. Two papers describe studies of structural changes accompanying metal fatigue and discuss the possibility of detecting these changes by means of a physical property (damping capacity). A unique feature of the Supplement is that it contains a contribution entitled "Physical Methods in Medical Diagnosis". The medical field is one in which non-destructive testing is of particular interest.

Volcanism in Asia

E. M. Murzaev (*Priroda*, No. 3, 90; 1957) has assembled a record of new discoveries of recent volcanicity in Siberia and Central Asia. There is a considerable body of evidence to show a very large extent of Quaternary volcanism in eastern Siberia and eastern and central Mongolia. Certain volcanoes were active in northern Manjouria in the eighteenth century. E. M. Murzaev, V. A. Obruchev and V. I. Vlodavetz have described well-preserved volcanic cones and lava flows in the Khingan and Darigang regions of Mongolia. Various travellers have also reported on volcanoes of Kuen-Lun and northern Tibet. There are also reports on active volcanoes in the Chinese province of Sintzian and other parts of China. In Tian-Shan and Pamir only volcanic rocks connected with fissure eruptions are known, and there are no traces of Quaternary volcanicity.

Polish Ephemerides

Rocznik Astronomiczny Obserwatorium Krakowskiego, 28 (1957), contains the ephemerides of eclipsing binaries, prepared by Dr. K. Kordylewski and his collaborators at Cracow Observatory. The present ephemerides contain 705 stars, a considerable increase over the 589 stars listed in the issue for 1956. At the end of the publication, tables of processional coefficients and of obliquity of the ecliptic, and also of occultations of stars by the Moon, are given. The first of these enables, by the use of simple formulæ, the calculations of the reduction of rectangular equatorial co-ordinates from the epoch 1957·0 to another epoch, and vice versa. The first two were computed by Dr. S. Andruszewski and the occultation tables by W. Wiśniewski, using T. Banachiewicz's method. The computations were made for the five Polish Observatories of Poznán, Wroclaw, Torun, Cracow and Warsaw.

Microchemical Journal

The first number of a new publication, *Microchemical Journal*, devoted to the application of microtechniques in all branches of science, has been received. It has an editorial board of well-known authorities and is published under the auspices of the Metropolitan Microchemical Society by Interscience Publishers, New York and London. The subscription price is 9.60 dollars per year, foreign postage 0.50 dollar per volume. The first part contains some interesting original papers and also brief abstracts of publications in the field. We wish the new journal every success.

Meeting of Nobel Prize-winners in Lindau

The annual meeting of Nobel Prize-winners is to be held in Lindau, Lake Constance, during July 1–5. The conference, which will be held in the Stadttheater, Lindau, will be devoted to various aspects of medicine, and the following addresses will be delivered: Prof. P. S. Hench (Rochester), "The Chemical and Experimental Uses of Cortisone"; Prof. Werner Forssmann (Bad Kreuznach), "Über Cardiologie"; Prof. Henrik Dam (Copenhagen), "Über einige Ernährungsversuche mit dem Goldhamster"; Prof. W. M. Stanley (Berkeley), "Relations between Viruses and Cancer"; Prof. Georg von Hevesy (Stockholm), "Krebsanaemie"; Prof. Gerhard Domagk (Wuppertal-Elberfeld), "Stand der Chemotherapie des Carcinoms"; Prof. Selman A. Wakaman (New Brunswick), "Antibiotics and their Social Significance"; Dr. Paul Hermann Müller (Basle), "Antibiotica in der Landwirtschaft"; Prof. Hans von Euler-Chelpin (Stockholm), "Anpassung und Resistenz"; Prof. Hugo Theorell (Stockholm), "Atmungsfermente"; Prof. Richard Kuhn (Heidelberg), subject to be announced. Also participating will be Prof. Kurt Alder (Cologne), Prof. Max Born (Bad Pyrmont) and Prof. Adolf Butenandt (Munich). The meeting will be of general interest to both medical practitioners and research workers, and opportunities will be provided for discussion. A comprehensive programme of excursions has also been arranged. Further details may be obtained from

the Ständiger Arbeitsausschuss für die Tagungen der Nobelpreisträger, Lindau im Bodensee, Postfach 11.

United States National Science Foundation : Senior Postdoctoral Fellowships

APPLICATIONS are invited by the United States National Science Foundation for a second group of senior postdoctoral fellowships to be awarded during the current calendar year. Fellowships will be awarded in mathematical, physical, medical, biological, engineering and other sciences, including anthropology, psychology (other than clinical), geography, certain interdisciplinary fields, and areas of convergence between the natural and social sciences. To be eligible for these awards, candidates must be citizens of the United States with special aptitude for advanced training and must hold the doctoral degree or have the equivalent in training or experience. Annual stipends to a maximum of 10,000 dollars, adjusted to match as closely as feasible the regular salaries of the recipients, may be applied toward study or research in an accredited non-profit institution of higher learning in the United States or abroad. A limited allowance to aid in defraying costs of travel for a Fellow and his dependants will also be available. Applications and further details can be obtained from the Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C.

Zoological Society of India

THE new Executive Council of the Zoological Society of India has been elected as follows : *President*, Dr. M. L. Roonwal, director, Zoological Survey of India, Calcutta ; *Vice-Presidents*, Dr. H. S. Rao, Katpadi, and Dr. G. S. Thapar, Lucknow ; *Editor*, Prof. R. V. Seshaiya, Annamalai University, Annamalainagar ; *Secretary*, Prof. P. N. Ganapati, Andhra University, Waltair ; *Treasurer*, Dr. B. S. Chauhan, Zoological Survey of India, Calcutta ; *Manager of Publications*, Shri K. Chidambaram, New Delhi ; *Members*, Dr. N. K. Panikkar and Dr. B. N. Chopra, New Delhi ; Dr. B. Prashad, Dehra Dun ; Dr. M. A. Moghe, Poona ; Dr. J. L. Bhaduri and Dr. H. N. Ray, Calcutta.

Royal Aeronautical Society : Officers

THE following have been appointed officers of the Royal Aeronautical Society for 1957–58 : *President*, Sir George Edwards ; *Past Presidents*, E. T. Jones, N. E. Rowe, Sir Sydney Camm ; *President-elect*, Sir Arnold A. Hall ; *Vice-Presidents*, P. G. Masefield, Dr. E. S. Moult, Air Marshal Sir Owen Jones ; *Honorary Treasurer*, Major G. P. Bulman ; *Secretary*, Dr. A. M. Ballantyne.

University News : London

THE following appointments in the University of London are announced : Dr. R. A. Buckingham, reader in physics at University College, to the post of director of the University of London Computational Unit ; Dr. R. S. Scorer, lecturer in the Department of Meteorology at the Imperial College of Science and Technology, to the University readership in applied mathematics tenable at that College.

Malaya

PROF. T. F. DIXON, of the Department of Biochemistry, Royal Faculty of Medicine, Baghdad, has been appointed professor of biochemistry in the University of Malaya, in succession to Prof. J. W. H. Lugg, who has gone to the University of Western Australia. Prof. Dixon hopes to be in Britain during July and August, when his address will be c/o The Royal Society of Medicine, 1 Wimpole Street, London, W.1.

Announcements

SIR EDWARD APPLETON opened the new Radio Research Station near Slough of the Department of Scientific and Industrial Research on June 20.

SIR HAROLD ROXBEE COX, a director of Wilmot Breedon (Holdings), Ltd., and of the Brush Group, Ltd., formerly chief scientist to the Ministry of Fuel and Power, and Dr. C. J. Smithells, managing director of Magnesium Elektron, Ltd., and a former director of research to the British Aluminium Co., Ltd., have been appointed members of the Council for Scientific and Industrial Research.

PROF. ROBERT MILLNER SHACKLETON, Jane Herdman professor of geology in the University of Liverpool, has been awarded the Liverpool Geological Society Medal for 1956–57.

DR. J. M. ROWSON, curator of the Museum of the Pharmaceutical Society of Great Britain, has been appointed head of the Department of Pharmacy in the Nigerian College of Arts, Science and Technology.

THE ninth meeting of the International Whaling Commission is to be held at 10 Carlton House Terrace, London, S.W.1, during the week beginning Monday, June 24.

THE twenty-fifth anniversary of the International Tin Research Council is to be marked by two open days, on July 10 and 11, at the Council's headquarters and laboratories, at the Tin Research Institute, Fraser Road, Greenford, Middlesex.

THE 1957 Electronics Exhibition and Convention, organized by the Northern Division of the Institution of Electronics, will be held at the College of Technology, Manchester, during July 11–17. Tickets for the Exhibition, which includes Manufacturers and Scientific and Industrial Research Sections, can be obtained from exhibitors or from the honorary exhibition organizer, Mr. W. Birtwistle, 78 Shaw Road, Rochdale, Lancashire.

A LECTURE organized by the Institution of Electronics will be held at 6 p.m. on July 5 in the Beveridge Hall of the Senate House, University of London. It will take the form of a joint lecture, illustrated by sound film and slides, on "The Theoretical Problems of Television Astronomy", by Dr. P. B. Fellgett, and on "The 1956 Opposition of Mars", by B. V. Somes-Charlton. The meeting is open to members and friends, and non-members are also invited. Admission tickets are available from the hon. general secretary, Mr. W. Birtwistle, 78 Shaw Road, Rochdale, Lancashire, or from Mr. C. H. Messenger, 38 Hainault Court, Forest Rise, London, E.17.

WE regret that in the article on the annual congress of the South-eastern Union of Scientific Societies published in *Nature* of June 15, p. 1231, Major Maxwell Knight has been confused with Capt. C. W. R. Knight, author and lecturer on bird life, who died on May 19.

THE FUTURE FOR NUCLEAR POWER

THE present strength of the United Kingdom in the field of commercial nuclear power is due very largely to the foresight and singleness of purpose which have always marked the activities of Sir Christopher Hinton. A paper by Sir Christopher having as its subject "The Future for Nuclear Power"* must therefore command the utmost respect. The argument presented in this Lecture is mainly concerned with the cost of electricity generated from nuclear power stations of existing design, the way in which the nuclear power industry will develop and the price at which it will be possible to generate nuclear power in the future.

As a starting point, Sir Christopher takes approximate figures for reactors of the type which have been ordered by the electricity authorities in the United Kingdom. These reactors which are now under construction are based on the Calder Hall design and use essentially the same materials. However, they are of larger size and their design has been optimized for power generation and not for the production of plutonium as at Calder Hall. The cost of power generation is made up in the following way when operating at 80 per cent load-factor:

	Pence per kWh. sent out
Depreciation (5 per cent interest and 20 years life)	0·37
Interest on fuel charge (5 per cent)	0·06
Fuel replacement charge	0·24
Operating expenses	0·06
Total	0·73
Credit for plutonium in irradiated fuel	0·07
Net cost	0·66

In this analysis the fuel cost is calculated on the basis of a figure of £20,000 per tonne of fabricated uranium in the form of complete fuel elements.

Two points call for special comment. It is to be noted that 65 per cent of the cost of electricity sent out arises from the capital charges in the case of these first nuclear stations. This is in contrast to a conventional coal-fired station where only about 25 per cent of the cost of electricity arises from these charges, but where the fuel cost is the major item. The second point to be noted is that the credit for by-product plutonium has been scaled down drastically from the level which was proposed at the time of publication of the original White Paper programme. The case for nuclear power resting on a substantial credit for plutonium production was never a very satisfactory one. Plutonium credit has now largely disappeared from the picture. Thanks to the successful engineering development of the gas-cooled reactor, however, it now seems reasonably certain that the cost of electrical power sent out from these first industrial stations, to be completed in 1960–61, will be only marginally higher than the cost of power produced from the best conventional stations completed at that date.

From this point Sir Christopher argues by analogy with the history of development of the coal-fired steam engine that the capital cost per horse-power or per kilowatt is likely to follow an exponential law of decrease. In view of the large proportion of the total cost of generation represented by the capital component in the case of the nuclear stations, it is concluded that a large reduction in generating cost will be possible in successive designs with the passage of years.

A possible criticism of this argument from history is that historical analogies are apt to be misleading, and it may easily happen that unrelated phenomena may yield a straight-line 'law' when quantities are plotted on a logarithmic scale.

This criticism, however, is at least partly answered in the paper, ". . . we are not entitled to assume these reductions in capital cost purely by the analogies of history unless we can predict how they may come about, and to do this it is once more useful to look back at the history of other prime movers. More than anything else, the reduction in the cost of steam power plants has been linked with the rise in the initial temperature which it has been possible to achieve in the steam cycle". The argument is then developed in some detail with a discussion of some of the engineering and metallurgical developments which may be expected to lead to increased heat ratings and higher working temperatures in future designs of nuclear reactor.

There can be no doubt at all that there will be a general trend towards higher ratings and higher temperatures with nuclear stations as in the case of other types of generating plant. Just how far this trend can be predicted in a quantitative manner, however, is open to question. There is at least one basic difference between nuclear and conventional thermal power plant which may affect the validity of the analogy. In conventional stations where energy is released by the combustion of fossil fuels, we necessarily start at the top of the cycle with a relatively high combustion temperature. The source of heat or furnace, however, is mechanically simple. Progress with steam plant has been concerned mainly with achieving higher steam pressures and temperatures, and the most difficult problems have arisen at the high-temperature end of the turbine, where large stresses and mechanical complexity are encountered in a region of high temperature. With a nuclear reactor, on the other hand, while theoretically the heat may be released at almost any temperature we please, the reactor core or heat source is itself a complex piece of structural and mechanical precision engineering. Formidable problems are to be expected in the operation of nuclear reactor cores at very high temperatures. The chequered history of the attempts to develop the gas turbine in large sizes for power generation which have been made during the past decade, provides a warning of the scale of difficulty that must be expected if too rapid an advance is attempted towards high temperatures in association with plant of mechanical or structural complexity.

Having sounded this note of criticism, however, it is necessary for the reviewer to point out that Sir Christopher Hinton has exhibited an unerring

* The Future for Nuclear Power. By Sir Christopher Hinton, F.R.S. (The Axel Axson Johnson Lecture delivered at Stockholm on 15th March, 1957.) Pp. 20. (Stockholm: Royal Swedish Academy of Engineering Sciences, 1957.)

instinct in the past for being right in his engineering judgments. He may very well be right again on this issue of the pace of development of nuclear plant towards higher working temperatures. That part of his paper which deals with the further development of the Calder Hall type of station is of the greatest interest. The British commercial designs of graphite-moderated gas-cooled reactor have already gained a commanding lead over rival American designs for liquid-cooled reactors. It now seems probable that the gas-cooled reactor may also prove superior in its capacity for future development. Certainly no responsible engineer or scientist could quarrel with Sir Christopher's statement that "the technology of design is advancing so quickly that manufacturing provision must be laid down on the basis of forecasts; its provision cannot follow in the wake of technical development".

J. M. KAY

OXIDATION OF PLANT PHENOLICS

INAUGURAL MEETING OF THE PLANT PHENOLICS GROUP

THE Plant Phenolics Group was inaugurated at a meeting held in the Department of Botany, University of Cambridge, on April 9. Dr. E. C. Bate-Smith, presiding, said that the idea of forming the Group originated from a succession of inter-laboratory symposia on tannins, hydroxyaromatic acids (see *Chemistry and Industry*, 478; 1956), etc., in plants, under the auspices of the Food Investigation Organization of the Department of Scientific and Industrial Research. These symposia attracted a diversity of interest not catered for by any single existing Society. The response received to the invitation to enrol in the Group is a clear indication of the need which is felt for an association to provide for these diverse interests. The enrolled membership numbers one hundred and twenty, and represents university laboratories, agricultural and forestry research institutions, food research laboratories, and various other industrial laboratories, in approximately equal numbers.

The objects of the Group were defined as "the advancement of the knowledge of the phenolic constituents of plants in respect of their function, biosynthesis, the effect on plant and animal physiology and pathology, and the application of such knowledge in industry and agriculture".

A provisional committee was elected as follows: Dr. E. C. Bate-Smith (Low Temperature Research Station, Cambridge); Dr. H. G. Harvey (British Food Manufacturing Industries Research Association, Leatherhead, Surrey); Dr. D. E. Hathway (British Leather Manufacturers' Research Association, Egham, Surrey); Dr. A. C. Hulme (Ditton Laboratory, Larkfield, Maidstone, Kent); Mr. W. W. Reid (Carreras Limited, Stanhope Road, London, N.W.1); Dr. E. A. H. Roberts (Indian Tea Association, Lafone Street, London, S.E.1); Dr. T. Swain (Low Temperature Research Station, Cambridge); Mr. A. H. Williams (Agricultural and Horticultural Research Station, Long Ashton, Bristol). Dr. J. Friend (Low Temperature Research Station) was appointed honorary secretary of the committee, *pro tem.* (*vice* Dr. T. Swain, absent abroad).

The inaugural meeting was followed by a symposium on "The Oxidation of Plant Phenolics", with Dr. J. Barker (Cambridge) presiding.

In a paper on "The Oxidation of Phenols" Prof. R. D. Haworth (Sheffield) enumerated the several chemical mechanisms by which phenols may be oxidized. With persulphate or Fenton's reagent, hydroxyl groups may be added either in *ortho-* or *para-* positions; these changes are often accompanied by shifts of *p*-methyl groups and elimination of *p*-aldehydic groups. Thus the oxidation of *p*-cresol to form homogentisic acid. Elimination of hydrogen takes several forms: the production of *o-* or *p*-quinones; the formation of diphenyl derivatives or diphenyl ethers; or the formation of peroxides. The oxidation of gallate esters to ellagic acid is an instance of the first type. Slightly more complicated bimolecular oxidations lead to such compounds as Pummerer's ketone from *p*-cresol. The fusion of rings and the formation of C—C bridges can also lead to the morphine and apomorphine skeletons from phenyl*iso*quinoline.

The very common phenolic compounds derived from phenylpropylene can be oxidized in the side-chain to form bimolecular structures such as those found in the lignans. It seems highly probable that the group of substances known as lignins are built up on this plan. Oxidations involving rupture of an aromatic nucleus lead to the formation of tropolones such as purpurogallin, and compounds such as brevifolin carboxylic acid and chebulic acid may be formed as products of ellagic acid oxidation.

The paper on "The *in vitro* Oxidation of Plant Phenolics" by Dr. D. E. Hathway (British Leather Manufacturers Research Association) was concerned with the way in which such chemical mechanisms as those described by Prof. Haworth might be involved in the formation of the larger molecules found in plant tissues, and especially those found in tanning extracts. These are of two classes, the one based on gallic acid and its oxidation products, and the other based on catechin-like substances and their condensation products. Aerobic autoxidation of gallate esters leads to ellagic acid and humic acids, but oxidation catalysed by mushroom polyphenolase proceeds preferentially to ellagic acid. The coincidence in the recorded systematic distribution of gallic acid with that of ellagic acid suggests that in some cases at least the latter may arise by enzymic oxidation of the former.

Studies of the autoxidation of *d*-catechin and a number of methyl-substituted catechins by manometric and spectrophotometric methods confirm that the oxidation proceeds by way of a quinone stage, followed by intermolecular C—C linkage. The evidence suggests that the most likely linkage is between either the 6 or 8 carbon of one molecule and the 2′ carbon of the second. Such 'head-to-tail' linkages might take place progressively leading to large molecules of a phlobatannin nature. Autoxidation and polyphenolase (tobacco and potato) oxidation of catechin gave polymers which had the same elementary analysis and physical properties, and were closely similar in these respects to phlobatannins from *Uncaria gambir* (gambier) and *Acacia catechu* (cutch). Since both species contain catechin epimers, there is a strong supposition that the phlobatannins present in the tanning extracts are formed from catechins by oxidative condensation.

In dealing with "Polyphenolases as Respiratory Enzymes", Dr. W. O. James (Oxford) summarized the evidence in favour of the function of polyphenol-

ases as terminal oxidases in the respiration of plants under four heads.

First, polyphenolases are widely distributed throughout plants and are capable of catalysing the oxidation of most naturally occurring phenols; secondly, enzymes exist in plant tissues which catalyse the reduction of quinones by reduced co-enzyme diphosphopyridine nucleotide, and an electron transfer can be visualized as occurring between their substrates and molecular oxygen; thirdly, the respiration of many plant tissues can be stimulated by the addition of small amounts of polyphenol; and fourthly, many substances which act as competitive inhibitors on polyphenolases or inhibit by complexing with the copper of the enzyme also inhibit the respiration of plant tissues.

Although such evidence at first sight seems impressive, if it is examined critically the conclusion cannot be avoided that proof of the participation of polyphenolases in a respiratory chain has still to be produced. Polyphenolases are not found in all plant tissues, and the fact that model respiratory systems can be constructed *in vitro* is not evidence that they so function *in vivo*. Many plant tissues, the respiration of which is stimulated by the addition of polyphenols, contain no polyphenolases and, in those tissues which do, stimulation of respiration may be achieved by the addition of substances such as 2-6-dichloroindophenol and by other dyes. Similarly the inhibition of respiration by substances such as *p*-nitrophenol can be seen with other tissues, for example, yeasts, in which no one would suggest that polyphenolases play any part in respiration. The inhibition of respiration by substances such as Dieca may well be due to the inhibition of other enzyme systems, such as those systems involving ascorbic acid oxidase. The case *against* a polyphenolase system is largely the case *for* a cytochrome system. It is possible, as H. S. Mason suggests, that the polyphenolases are concerned in the further oxidation, by dehydrogenation or introduction of hydroxyl groups, of simpler phenolic constituents to such complex products as lignin.

Dr. C. Weurman (Central Institute for Nutrition Research, Utrecht) read the fourth and last paper on "The Oxidation of Phenols in Injured Plant Tissues". The situation is one in which the tissue is dead or in a state of rapidly approaching death. Studies of isolated enzymes *in vitro* are of no help when the complete chaos of the dying cell is the object of study. As one example of the way enzyme systems interact in such a system, phenoloxidases are frequently inactive towards glycosides, and it will therefore be of importance whether or not active glycosidases are present along with phenoloxidases in the complex system. After discussing results which had been obtained with purified enzymes, Dr. Weurman described his own work with enzyme mixtures from potatoes and mushrooms acting on a large number of naturally occurring phenolic glycosides and aglycones. Only very few of the glycosides were not attacked by these enzyme preparations. Dr. Weurman briefly outlined the part played by oxidation of phenols in the development of desirable commercial quality in tea, cocoa, and cider, and invited discussion in greater detail from the experts in those commodities present at the meeting. A written contribution on polyphenols in fruits to the discussion of Dr. Weurman's paper was submitted by Dr. A. C. Hulme (Ditton Laboratory, Kent).

E. C. Bate-Smith

FITTING THE JOB TO THE WORKER

An international seminar under the title "Fitting the Job to the Worker", organized by the European Productivity Agency, was held at Leyden during March 28–April 3. It was attended by about seventy people, from thirteen European and North American countries, comprising physiologists, psychologists, engineers and industrial physicians in about equal numbers; the aim was to bring out what each has to contribute to the scientific study of the industrial worker as he uses his tools and equipment and as he is affected by his immediate environment, and how such knowledge can be applied to the design of machine and work-place either to increase the effectiveness with which the job is done, or to improve the worker's well-being. Welcoming the participants, Dr. Alexander King (deputy director of the European Productivity Agency) said that the Agency is giving increasing attention to the application of the human sciences to industrial problems linked with productivity. This gathering was to provide opportunity for a full and frank exchange of views between scientists from different countries; and it should help the European Productivity Agency to see further action it could take, bringing together as it does employers, trade unionists and scientists.

The nucleus of the seminar was a small team from different countries which had spent two months in the United States to study activity there in the field of industrial physiology and engineering psychology —the field for which the name 'ergonomics' has developed in Britain. Mr. K. F. H. Murrell, of the Department of Psychology at the University of Bristol, speaking of the visit, commented that nearly all the research in the 'human engineering' field appears to have been done in a military context, and to have concerned itself largely with high-stress situations which do not arise in industry; the effects of long-continued work at normal stresses still await study, and pending this, there may be danger in premature translation of military results to the industrial field. Prof. H. S. Belding (Department of Occupational Health, University of Pittsburgh), who was United States adviser to the team, commented on its impact in stimulating contact in the United States between the different types of scientists. Also they had not previously experienced the three-sided approach by scientists, employers and unions. The problems needing study are very similar in the United States and in Europe; physical stress has been reduced ("the hardest physical effort of the worker is now that of the housewife"), and the lighting of factories has improved tremendously over the past twenty years; but in new factories some jobs are hotter than ever, and noise-exposure is probably increasing.

The seminar divided into two groups for discussion of particular fields, with short notes in advance by participants on relevant work in progress in their own country. One group discussed the physiological assessment of heavy muscular work and heat-stress, and next day turned to the effects of noise, and noise-abatement. A joint contribution from Dr. F. H. Bonjer, of the Department of Occupational Medicine at the Netherlands Institute for Preventive Medicine, and Dr. D. van Zuilen, of the T.N.O. Research Institute for Public Health Engineering, showed impressive collaboration between the physiologist

and the engineer to carry out surveys of the noise at work places and of the hearing-loss of the people there. With equipment in mobile vans, it now takes only ten minutes to obtain the complete frequency-spectrum of a person's hearing-threshold, and it was pointed out that such a curve may contain a deep 'dip' so narrow that it would be overlooked by measurements at octave-spaced spot-frequencies. Two work places with the same total noise-level but different frequency-distributions (for example, cotton spinning and weaving sheds) may cause very different hearing-losses in the course of, say, ten years; so as well as recording total noise-level, it is necessary to analyse the frequency-spectrum. For places where noise fluctuates, they have developed an instrument which analyses the noise by octave bands and integrates automatically the total time (during a one-hour observation period) for which the noise-level exceeds the first or second of two pre-set levels. Comparable research on the effects of noise is in progress in other countries, including Germany, Sweden and the United States.

The parallel group was concerned with primarily psychological problems; and it appeared that whereas all the countries represented are doing work on physiological problems of interest to industry, competent specialists who can be called engineering psychologists are more or less confined to Britain and the United States. Besides discussions on engineering psychology, especially design of machine controls, and on motivations and satisfactions arising from the nature of the work itself, a day was given to discussing display of information, dealing both with the study of pointer-and-scale and other display instruments and panels and with information from sources not specially intended as such. Mr. J. Spencer, of University College, London, in outlining the various types of display, referred especially to results from his own research on the best forms of graduation for scales. Discussion emphasized the importance of information 'displayed' other than visually—for example, to the kinæsthetic sense of position or (especially) to hearing: every machine or process has characteristic sounds which are used by the operators to know how it is going, though design engineers usually overlook the importance and potentialities of this, and much further study is needed of the properties and capabilities of the different senses as information-channels. Both groups joined for a discussion on anthropometry, physiology and psychology applied to working postures and machine-design, which showed marked variety in the interests developed in different countries. Thus, the relation between machine-dimensions and operator-posture was approached from the engineering point of view by Dr. B. Schulte, of Siemens-Schuckert A.G., Germany, and by Mr. B. Hellern, director of the Research Institute of Production Engineering, Oslo. Starting from psychology, researches on the design of machine-controls were described by Mr. R. G. Sell, of the British Iron and Steel Research Association, and Mr. W. T. Singleton, of the British Boot, Shoe and Allied Trades Research Association. Outstanding as an inter-disciplinary exercise was the design of driver's seat and controls for a tractor-mounted hoe developed by the National Institute of Agricultural Engineering, the need being to steer with an accuracy of about half an inch along the line of plants to be hoed; Mr. K. Provins, of the Department of Human Anatomy of the University of Oxford, described the various anatomical and physiological considerations taken into account, while discussion brought out possible psychological effects worth study, due to the relative movement of hoe and plants or to the influence of position and colour of chassis-members in building up the driver's visual field.

Training needs in the field of ergonomics were discussed on the last day. In all countries, trained people are very few. At the Ph.D. level, Prof. S. D. S. Spragg, of the University of Rochester, indicated his training of experimental psychologists; the need is for engineers, physiologists and psychologists thoroughly trained in their own disciplines and with enough knowledge of the other two to collaborate in joint research. The biggest immediate need, however, and one which came out again and again during the whole seminar, is for some simple training in the field of ergonomics for production engineers and designers at the graduate and technologist levels, since straightforward applications of existing knowledge can now lead to big results. Various small-scale but promising beginnings were indicated, notably by Prof. S. Forssman, of the Swedish Employers' Confederation, and by Prof. E. Grandjean, of the Swiss Federal Institute of Technology, Zurich; and the seminar recommended various steps to bring the need and possible courses before universities and colleges of technology.

Altogether the week was profitable and stimulating, justifying the remark that never before in this field had so well-balanced a group met, from so many countries. An informal committee, with Prof. Grandjean as corresponding secretary, was charged with exploring ways of continuing international contact between 'human work' scientists; and there was every sign that the various participants were going from Leyden with fresh ideas and determination to broaden and intensify research in this field in their own countries.

R. G. STANSFIELD

INTERNATIONAL STARCH CONVENTION

THE seventh International Starch Convention was held at the Cereal Research Station, Detmold, Germany, during April 24–26. Among the two hundred and forty chemists who attended, there were eighty from abroad representing twenty-one countries. The papers which were read to the meeting were divided into three sessions, on research and analysis; starch manufacture; and on starch fractions and derivatives.

Following the actual Convention, a conference was held on April 27, attended by representatives from fifteen countries, for the purpose of discussing the possibility of standardizing the analysis of starch, its derivatives and by-products, on an international level. The meeting decided that this could best be done under the auspices of the International Organization for Standardization and that this body should be approached with the request for the organization of the necessary working committees in the various countries. The meeting then discussed the report of two *ad hoc* committees, which had already carried out surveys of methods employed for the determination of protein in starch and the assessment of starch qualities.

The first session of the Convention was opened by Prof. M. Samec (Ljubljana, Jugoslavia), who

discussed the influence of various starches and starch derivatives on the mechanical strength of paper. In general, he found that wheat and rice starches were more efficient in this respect than starches from other plants. Fractionating individual starches, it was found that sizes made from amylose produced paper of greater strength than amylopectin sizes. Investigations had also been undertaken to decide whether it was more advantageous to add the requisite starch size to the cellulose pulp in the beater or whether the paper sheets should be dipped into the size solution (tub size). It was found that by adopting the latter procedure the mechanical strength of paper could be increased up to 900 per cent. Properties which were tested included folding endurance, stretch, and tearing and tensile strength. Some relation was also found between the infra-red spectrum of starch, the rate at which the starch was adsorbed by the cellulose fibres and the accompanying increase of mechanical strength.

Prof. J. Holló (Budapest) showed that during the amperometric titration of starch with iodine there was some free iodine present in the solution before the end-point of the titration had been reached. The concentration of the free iodine was proportional to the concentration of potassium iodide, to the degree of polymerization of starch and to the temperature. The heat of reaction was calculated and corresponded to the formation of hydrogen bonds between iodine and hydroxyl groups.

An account of the action patterns of starch-metabolizing enzymes was given by Dr. W. J. Whelan (Lister Institute, London). He presented a scheme showing how amylose and amylopectin might be synthesized and deposited side by side in the starch granule. By treating native starch with the appropriate enzyme, it was possible to de-branch the amylopectin component, thus producing a polysaccharide with the characteristics of amylose. With other enzymes it was also possible to ramify the otherwise linear amylose molecule, thus giving the starch the properties of amylopectin.

Dr. E. Dux (Richmond, Surrey) described the use of electrophoresis for the investigation of industrial starch and dextrine products. Using strips of fibre-glass paper in a ridge-pole type tank at relatively low voltages, the method was found suitable for the classification of white and pyro-dextrins. It was also useful for the detection of polar groups in starch products and the separation of polysaccharides and monosaccharides for quantitative analysis.

The analysis of the constituents of glucose syrups, manufactured for food purposes by acid hydrolysis of starch, was described by Prof. F. Schneider (Brunswick). Using paper chromatography, the mono- and oligo-saccharides present in such syrups could be readily resolved, and details were given of suitable solvents and developers. The method was used for following the mechanism of degradation and reversion reactions occurring during manufacture of starch syrups. Mention was especially made of the analysis of oligosaccharides which were formed by the heat treatment of glucose and fructose in acid or alkaline media.

Prof. W. Smirnow (Leningrad) reported his investigations concerning the products formed by the acid hydrolysis of starch. The dextrins which appeared during the reaction had been isolated, and their properties determined. The decomposition of glucose in acid medium was investigated and the *p*H limits for maximum stability were given. Reversion products and coloured substances produced by the acid decomposition of glucose have also been isolated and characterized.

It has been known for some time that the discoloration of starch syrups is due to two causes: first, the Maillard reaction between proteins and their degradation products with aldehydes (sugars), and secondly, the decomposition in light of hydroxymethyl furfural. It has now been found by J. Borud (Lillehammer, Norway) that the amount of soluble amino-acids present in starch hydrolysates could be appreciably reduced by employing initial starch suspensions of considerably higher concentration than hitherto common. The remaining nitrogen-containing substances were present in the syrup as insoluble protein which did not cause discoloration.

Another method of purifying starch syrups was explained by Dr. G. de Jong (Amsterdam). Here the hydrolysate was passed through a system of four ion-exchange resins arranged in series. Preliminary decoloration was carried out with a porous and strongly basic resin. Remaining amino-acids were then removed by anion and cation exchange resins. Lastly, hydroxymethyl furfural was removed by an anion exchange resin which had been saturated with sulphur dioxide.

Various methods used for the determination of water in starches were discussed by Dr. E. Eberius (Duisburg). Mention was made in particular of the Karl–Fischer method and its application to the field of starch. Two variations of this technique were used, namely, the direct titration of ungelatinized starch granules with the reagent, or preliminary dispersion of the granules in anhydrous methanol. It was found that the former method gave values for the water content which were consistently 0·15 per cent less than values from the latter. The water content obtained by direct titration also corresponded to that given by oven drying. It was considered likely that methanol caused some diffusion of water out of the interior of the starch granules.

All papers presented to the Convention and the discussion which followed each one will be published in due course in the journal *Die Stärke*.

E. Dux

COLONIAL DEVELOPMENT CORPORATION

REPORT FOR 1956

THE annual report of the Colonial Development Corporation* for the year ended December 31, 1956, records a surplus of £572,809 after paying all outgoings, including £416,173 Colonial Office interest, the net operating profit from direct projects and subsidiaries being £371,718, compared with £113,165 in 1955. The only substantial loss was on re-opening the Macalder–Nyanza Mines, Ltd., but better results are expected when the initial difficulties are overcome and the efficiency improved, provided that the price of copper does not fall much further. Eight new projects were initiated by the Corporation during the year, bringing the total to sixty-six continuing projects and investigations, compared with sixty-

* Annual Report and Statement of Accounts of the Colonial Development Corporation for the year to 31.12.56. Pp. v+57. (London: H.M. Stationery Office, 1957.) 3s. net.

three in the previous year, representing a total approved capital of £74·2 million, of which £45,753,000 was deployed at the end of the year. Of these projects, sixteen are in the Caribbean, eight in the Far East, fifteen in East Africa, seven in Central Africa, twelve in High Commission Territories, and eight (including one in Ghana) in West Africa. Functionally, thirteen projects and 18·6 per cent of deployed capital were in agriculture; six projects and 4·5 per cent capital in animal projects; eight projects and 7·0 per cent capital in factories; one project and 0·3 per cent capital in fisheries; four projects and 11·2 per cent capital in forestry; two projects and 0·5 per cent capital in hotels; nine projects and 12·7 per cent capital in minerals; eight projects and 12·5 per cent capital in property and housing; nine projects and 27·5 per cent capital in power; and six projects and 5·2 per cent capital in transport and communications.

While the projects controlled by the Corporation are in much better shape as revenue-earners than before, the report points out that the three outstanding issues in 1955 are still unsettled. The 'special losses' on pre-1951 commitments abandoned wholly or in part were assessed last year at £8,020,441, and even if the Secretary of State's power to waive interest is exercised in full, it does not relieve the Corporation of its obligation to repay the 'special losses' capital. The load cannot be carried by other projects, which can probably do no more than service their own capital, particularly if, as has been argued by the Colonial Office, the Corporation should not be allowed to embark on undertakings for which alternative finance is available. Lord Reith points out trenchantly that, on this argument, it would become impossible for the Corporation to associate with credit-worthy borrowers, who obviously would allow neither the Corporation nor the Government to test the market nor provide any certificate likely to damage their credit.

On the interest question, the report points out that, borrowing at the present level (4·25 per cent for short-term, 5 per cent for medium-term and 5 per cent for long-term loans, fixed on February 16, 1957—compared with 4 per cent, 5 per cent and 4·75 per cent at January 17, 1956), new projects must show equivalent high returns, and the Corporation is faced with completing existing jobs with money now costing almost double the rate at which the projects were budgeted. This policy slows down Colonial development more than is necessary or desirable, and in March 1956 the Corporation was presented with a new schedule of annuities payable, revoking the previously agreed interest-free period to March 31, 1957, and involving additional interest of more than £957,000.

The third outstanding issue relates to the powers of the Corporation, and although the Overseas Resources Development Act, 1956, which became law on August 2, 1956, removed some doubts as to the validity of past activities, it created fresh doubts, for example, as to the validity of Southern Rhodesian undertakings. Lord Reith also offers a strong protest at the exclusion of the Corporation from territories emerging into independence. The Corporation was informed in August that the Government did not contemplate the starting of new projects after a Colony became independent, and in November the Corporation was told that certain new schemes for Ghana and Malaya were to be arbitrarily excluded, while a clause in the Ghana Independence Bill excluded Ghana from the term 'colonial territories' in the Overseas Resources Development Acts, 1948 to 1956. Both Ghana and Malaya have protested at the loss of the Corporation's help, and Lord Reith urges that it is common sense that the Corporation's services should be available to both emerging and emerged members of the Commonwealth.

MIGRATIONS OF HUMPBACK WHALES

THE migrations of whalebone whales in the southern hemisphere have long been of interest, and those of the humpback whale (*Megaptera novaeangliae*) were among the first to be recognized by the whalers working at South Georgia and on the African coasts in the early years of this century. In later years Australian, British, Norwegian and other workers assembled further evidence of these migrations, and their conclusive demonstration between Antarctic waters and the north-west coast of Australia, and the waters off Madagascar, was an immediate result of the whale-marking undertaken in the Southern Ocean by the *Discovery* Committee in the 1930's. W. H. Dawbin has now extended our knowledge of the movements of humpback whales in the Pacific Ocean by his study of records of some 9,000 individuals of this species in New Zealand coastal waters (*Trans. Roy. Soc. N.Z.*, **84**, 1, 147; 1956). These records, which include the catch statistics of shore whaling stations; sightings by lighthouse keepers, coastal vessels and aircraft pilots; and data from old logbooks, diaries, etc., have been combined to give a clear picture of the northward and southward migration routes. Northbound whales pass mainly along the east coasts of New Zealand, but there is one group passing through Cook Strait to the west coast of North Island, and another moving around the south-west corner of South Island. South-bound whales pass mainly down the west coasts, but some follow the east coast of North Island as far as East Cape. Records of 'out of season' whales sighted in January, February and March are of interest in view of the evidence which is accumulating of the presence of some whalebone whales in the warmer latitudes when the bulk of the population has migrated south to the Antarctic.

The seasonal variation in the date and duration of the migration and in the relative abundance of whales passing in different years has been studied, and the rate of migration along the coast has been calculated at approximately 220 nautical miles a week in a direct north–south line. It is evident that this slow overall rate of advance is the result of frequent periods of rest and random movements on a large scale, since the cruising speed of humpback whales on passage has been observed to average 4–5 knots and it is known that individual animals may travel up to 500 miles at an average speed of more than 3 knots.

Dr. Dawbin is to be congratulated on the detailed picture he has built up of the movements of this whale in New Zealand waters. More information about its migrations in the Pacific Ocean as a whole will come from his work in organizing the whale-marking programme, and the collection of observations of humpback whales among the island groups of the South Pacific.

S. G. BROWN

PHYSICAL PROCESSES IN CLOUDS

AN important observational contribution to cloud physics is published in the *Monthly Weather Review* (United States Weather Bureau), December 1956, in the article on "Cloud Systems and Precipitation Processes in Pacific Coast Storms", by W. H. Hoecker, jun. The paper summarizes observations made during many flights into depressions over the State of Washington, during the winters of 1952–53 and 1953–54, by aircraft of the Weather Bureau's Artificial Cloud Nucleation Project. During these flights the aircraft would remain nearly over one spot while the clouds passed by and the flight meteorologist kept a detailed log and took photographs. Also, cloud particle samples were taken, and air temperature, air speed, pressure altitude, and icing rate were automatically recorded.

A situation often observed was one of multi-layered clouds, with an upper layer primarily composed of supercooled droplets in which ice crystals were produced. These crystals fell down to liquid cloud layers at lower levels in which they appeared to grow rapidly, finally producing rain-size drops. The crystals were visible as a haze just below the generating layer, but farther down were visible as light streaks against the aircraft structure. The water cloud often appeared to develop upwards into the ice-crystal generating layer. On one occasion when an ice generating layer did not completely cover a lower cloud layer the effects of natural seeding could be seen directly. In the seeded part the top of the lower layer was fuzzy but in the untouched part the average level of the top was higher, and cumulus domes were sharply defined. The difference is clearly shown in two photographs. On another occasion isolated showers of natural ice-crystals from above could be seen to be producing holes in a lower layer beneath them. This report is believed to be the first actual observation of natural seeding by ice crystals from a higher layer.

The samples frequently revealed a mixture of droplets favourable for coalescence with large droplets between 100 and 200 microns in diameter and small ones between 20 and 40 microns, thus providing the high values—up to 75/1—of terminal velocity ratios very favourable to coalescence of droplets. On one flight, when the pilot was endeavouring to climb out of a heavily ice-forming cloud, a mixture of velocity ratio of 100/1 was found. A mixture of droplets and ice-crystals was also encountered with velocity ratios up to 150/1 between crystal and droplet and hence very favourable to accretion of the droplets on the crystals. A photograph is reproduced of two droplets attached to a crystal. It is to be hoped that if future flights are made it will be possible to examine the upper ice-generating layer more fully and observe the generation of the crystals.

A NEW METHOD OF OBSERVING MAGNETIC TRANSFORMATIONS

By Dr. M. BLACKMAN, G. HAIGH and N. D. LISGARTEN
Physics Department, Imperial College of Science and Technology, London

IN experiments described below it has been possible to demonstrate magnetic transformations visually on the fluorescent screen of an electron diffraction camera, and to photograph the various stages in the transformation. The electron diffraction camera was used in conjunction with a cold unit designed for other work[1], as most of the transformations of interest occurred below room temperature. Two methods of observing the magnetic effects were employed. In the first the electron beam was focused above the specimen to be examined; in addition, a small movement of the focus was provided by the magnetic field of a pair of coils carrying alternating current. (This movement of the focus produces in addition the doubling effect observable in all the magnetic shadow patterns.) A shadow pattern of the specimen was thereby produced which, for hæmatite (αFe_2O_3), showed a cycloid-like character associated with the field of magnetic domains[2]. In the second method, used mainly when the specimen consisted of compressed powder, the electron beam was focused on the fluorescent screen; the field of the coils was used for forming a line trace on which the magnetic field of the specimen produced a characteristic change. The results obtained with these methods will be described briefly below.

Crystals

(i) *Hæmatite.* It has been shown by Morin[3], Néel and Pauthenet[4] and others, that hæmatite undergoes a magnetic transformation in the neighbourhood of 260° K. Hæmatite is an essentially antiferromagnetic substance, rhombohedral as regards its crystal structure, and possesses in addition a parasitic ferromagnetism; this consists of two parts, one of which disappears below 260° K. This part is stated by Néel[5] to be anisotropic and dependent on the direction in the basal plane. The other part is considered to be isotropic at all temperatures. The origin of the ferromagnetism is not yet clear, though several explanations have been put forward by Néel.

The shadow pattern produced by a crystal of hæmatite at room temperature is shown in Fig. 1*a*.

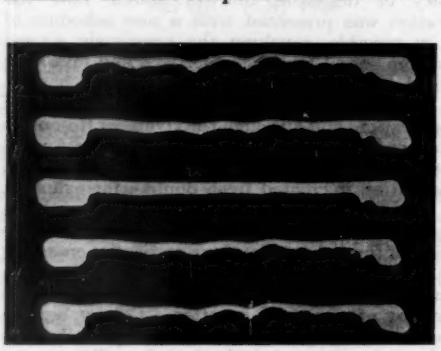

Fig. 1. Shadow patterns of a hæmatite crystal showing the magnetic transformation in the neighbourhood of 260° K.

As the crystal was cooled through the transformation point, this typical pattern faded (Fig. 1*b*), leaving a shadow pattern of the crystal surface (the central part of Fig. 1*c*). As the temperature was raised, the characteristic magnetic pattern reappeared (Figs. 1*d* and *e*). One of the surprising features of the patterns is the remarkable 'memory' displayed by hæmatite (compare Figs. 1*e* and *a*).

Crystals of hæmatite from both Elba and Etna have been examined. These showed the same transformation and the same general features. The crystals have well-developed faces and give diffraction patterns characteristic of single crystals.

(ii) *Magnetite.* A magnetic transformation is known to occur in magnetite between about 110° and 120° K., the transformation being extremely sharp (a few degrees at most). The magnetic properties of the crystal are found to be much more strongly dependent on direction in the crystal below the transformation temperature than above it[4].

A crystal having well-developed octahedral faces (source: Binnenthal, Valais, Switzerland) was examined. This showed no appreciable magnetic effects above the transformation temperature (Fig. 2*a*). A marked change was observed at about 120° K., the main effects developing within 2 deg. (Figs. 2*b* and *c*). The transformation point was found to be reversible (within experimental error); the magnetic pattern did not, however, show the accurate 'memory' found in the hæmatite crystals.

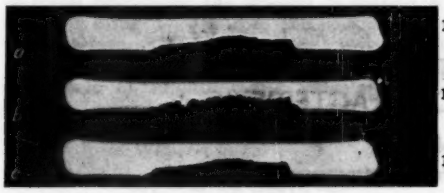

Fig. 2. Shadow patterns of magnetite showing the sharp magnetic transformation in the neighbourhood of 120° K.

(iii) *Pyrrhotite.* The change in the magnetic properties of a crystal of pyrrhotite with temperature have been described by Néel[5]. This crystal showed no ferromagnetic properties above 250° K.; below this temperature the saturation magnetization increased. The crystal structure was found to be orthorhombic and the magnetization anisotropic. Along the *c*-axis the magnetization passed through a maximum at 50° K. Néel explains the ferromagnetic properties as due to the gradual ordering of vacancies in the non-stoichiometric iron sulphide. This explanation, though plausible, is admittedly tentative and does not account for all the properties observed.

In the present experiments, two crystals were examined, the source of the first being San Juan del Rey Mine, Minas Cerais, Brazil, that of the second Sudbury, Ontario. The first showed features which had some similarity to those described by Néel. The

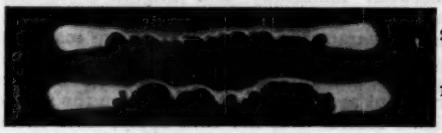

Fig. 3. Shadow patterns of pyrrhotite (Brazil) showing magnetic effects at two temperatures

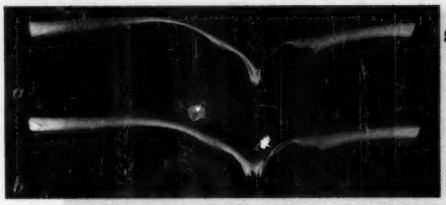

Fig. 4. Shadow patterns of pyrrhotite showing little magnetic change on cooling

crystal showed, however, magnetic effects at room temperature (Fig. 3*a*); there was a marked increase in the size of the magnetic features at about 170° K., followed by a slower increase as the temperature was further lowered (Fig. 3*b*).

The second crystal showed a completely different behaviour. It was markedly magnetic at room temperature (Fig. 4*a*) and the pattern remained substantially unchanged at lower temperatures (Fig. 4*b*).

These two examples show that the features described by Néel are by no means typical. While no doubt the vacancy mechanism postulated by Néel will play a part in the magnetic properties, pyrrhotites are known to contain appreciable quantities of nickel in the form of pentlandite (nickel sulphide) and the effect of this may have to be taken into account. (We are indebted to Dr. A. P. Millman, of the Department of Mining Geology, Imperial College of Science and Technology, for information on this point.)

Powder Specimens

A number of interesting magnetic substances are obtainable only in powder form, which can be investigated once these powders are compressed into a flat disk and magnetized. The direction of magnetization was arranged to be in the plane of the disk. The magnetic field of the disk has the effect of changing the electron line trace into a cycloidal curve, the detailed character depending on the strength of the field and the orientation of the disk. This method was used for examining maghæmite (γFe_2O_3), magnetite and hæmatite. The results for hæmatite were much as expected from direct measurements of Haigh[7] on powder specimens; this served as a check on the method. The magnetite

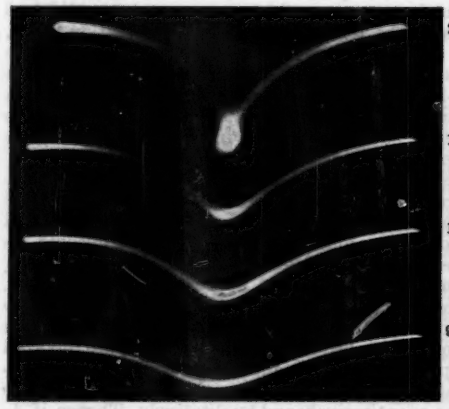

Fig. 5. Electron line trace patterns showing the changes in magnetic effects during the cooling of a magnetized disk of compressed magnetite powder

Fig. 6. Shadow pattern of a specimen of maghæmite (Transvaal) showing no appreciable magnetic change on cooling

disk showed the transformation at about 115° K., but the transformation occurs over a temperature-range wider than that found for the crystal (see paragraph ii above and Fig. 5).

Two specimens of maghæmite (one being from Bon Accord, Transvaal, and the other, a synthesized sample) were examined; these showed no appreciable change between room temperature and the temperature of liquid air (Fig. 6). This difference allows one to distinguish easily between maghæmite and magnetite, a distinction which is by no means simple to make on other grounds. Both are highly magnetic cubic crystals of similar symmetry and with only slightly different lattice spacings. There is also a tendency for these oxides to be non-stoichiometric and to contain impurities in their natural state. There appears to be reason for believing that many lodestones are in fact composed of maghæmite rather than magnetite[8]. The technique described above forms a rapid and certain method of deciding between the alternatives.

Specimens of ferrites have also been examined by this technique. The reversing spinel ($Li_{0.4}Cr_{1.2}Fe_{1.4}O_4$) described by Gorter[9] has been investigated and shows the curvature of the electron trace reversing at a temperature of 310° K. For this purpose the 'cold unit' could still be used. For higher temperatures the specimen can be attached to a small hot plate with which a temperature of 700° K. can be reached without difficulty.

Thanks are due to Dr. G. F. Claringbull, keeper of mineralogy at the British Museum (Natural History), South Kensington, London, for the loan of specimens of natural crystals.

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COMBINATION OF PHOTORECEPTOR RESPONSES IN THE PHOTOPIC LUMINOSITY CHARACTERISTIC

By C. E. M. HANSEL
Department of Psychology, University of Manchester

PHOTOMETRIC comparisons in which adjustments are made until two halves of a test-field appear identical involve measurement of the relative amounts of the two stimuli necessary to bring about this equivalence. It is assumed that the identical appearance of the two halves of the test-field results from similar responses in those areas of the retina and higher centres which correspond to the two halves of the test-field. At low illumination-levels, when scotopic vision is in use, discrimination of hue is lacking and it is possible to match lights of different wave-lengths so that they appear identical. At high illumination-levels, however, when photopic vision is operative, such matches are impossible as differences of hue are present.

The scotopic luminosity characteristic can be determined in two ways, first as absolute threshold measurements, made at different wave-lengths, and secondly, at values above the absolute threshold, as the relative luminosities of lights of different wave-lengths which give equal appearance of brightness. As there is brightness discrimination but not hue discrimination, it may be argued that two stimuli W_1 and W_2 applied in amounts S_1 and S_2 are reported as appearing identical, and that therefore the physiological responses induced by these two stimuli are similar quantitatively and qualitatively. Thence, if A_1 and A_2 be the fractions of the stimulus light absorbed in the retina and initiating photochemical action:

$$A_1S_1 = A_2S_2 \qquad (1)$$

Thus values of S as determined at different wave-lengths may be expected to vary inversely with the fraction of light absorbed in the retina. This argument is supported by the fact that the scotopic luminosity characteristic, at threshold values, agrees closely with the wave-length absorption characteristics of visual purple.

The photopic luminosity characteristic shows the luminosities of lights of different wave-lengths which appear, to an observer, to be of equal brightness when a difference of hue, although present, is disregarded. It is sometimes represented by plotting the reciprocals of the luminosities, thus giving values which increase with the brightness of the part of the spectrum being viewed. It does not represent the variation of brightness with wave-length since, under conditions in which the measurements are made, brightness is constant and we know that the relationship between luminosity and brightness is not necessarily linear. Thus in measuring the photopic luminosity characteristic, adjustments are made to two halves of a test-field until there is equivalence of brightness, and differences of hue are disregarded. The argument as to similarity of action on the retina and higher centres does not then apply, since there must be a difference in the nature of the physiological response for colour discrimination to occur.

There are two types of theory as to the part played by colour receptors in determining 'brightness' or intensitive experience: (1) that there is a separate 'brightness perceiving' mechanism, the colour receptors acting as modulators for hue; (2) that the contributions of the separate colour receptors, in respect of brightness, sum to give the photopic luminosity characteristic.

In the case of (1), measurement of the photopic luminosity characteristic may be considered as a measurement of the quantities of light at different wave-lengths required to give equivalence of activity in the mechanism of brightness perception.

In the case of (2), however, it is doubtful whether this type of reasoning is valid, since in this case there cannot be identity of physiological action. On the basis of the trichromatic theory, three types of receptor are being stimulated at one wave-length so that the experience of brightness resulting from that stimulation is similar to that which would result from their stimulation to different relative extents by other wave-lengths. The photopic luminosity could only be considered as varying directly with the arithmetical sum of the amounts of stimulation if the relationship between amount of stimulus and amount of experience (or sensation) were linear, but this does not appear to be the case. Thus if a non-linear relationship, as implied by Weber's law, gives a better approximation to empirical findings than a linear relationship, the conditions will be as follows.

Adjustments are made until stimuli W_1, W_2 appear of equal brightness, the amount of stimuli W_1, W_2 required being I_1, I_2. Let the sensitivities of the colour receptors be B_1, G_1, R_1, at wave-length W_1; B_2, G_2, R_2, at wave-length W_2; and let the resulting experience of brightness (or sensation) expressed quantitatively be represented by Sb_1, Sg_1, Sr_1 and Sb_2, Sg_2 and Sr_2.

Then from Weber's law:

$$Sb_1 = K \log (I_1B_1), \text{ etc.} \quad (2)$$

and for wave-length W_1:

total brightness $S_{W_1} = Sb_1 + Sg_1 + Sr_1$ and

$$S_{W_1} = \log (I_1B_1) + \log (I_1G_1) + \log (I_1R_1) \quad (3)$$

For wave-length W_2:

$$S_{W_2} = \log (I_2B_2) + \log (I_2G_2) + \log (I_2R_2) \quad (4)$$

Hence:

$$I_1^3 (B_1G_1R_1) = I_2^3 (B_2G_2R_2) \quad (5)$$

If comparisons are made relative to I_1 (so that $I_1 = 1$), B_1, G_1 and R_1 have fixed values, and hence:

$$I_2 = \frac{K}{\sqrt[3]{B_2G_2R_2}} \quad (6)$$

Thus the relationship between the photopic luminosity and the sensitivities or light absorption characteristics of the colour receptors would be of the form:

$$3 \log P = \log B + \log G + \log R \quad (7)$$

It will be seen from (7) that, if the absolute threshold of any receptor is not exceeded at any wave-length, the value log 0 will be involved which will reduce P to an infinitely large negative value. Alternative equations to express the relation between sensation and stimulus have been suggested which take into account deviations from Weber's law at the extreme values[1-3]. If these are substituted in the above argument this difficulty does not arise.

In some theories of colour vision, attempts have been made to determine the sensitivity characteristics of photoreceptors which will both account for colorimetric data and also give by summation the photopic luminosity characteristic. Attempts have also been made to account for the photopic luminosity characteristics encountered in various forms of colour defect in terms of the absence of particular types of photoreceptor. These calculations have involved arithmetical summation and they might be reconsidered in terms of other types of summation as described above.

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A NEW DETECTION OF FATIGUE DAMAGE IN METALS

By Dr. A. J. KENNEDY*
British Iron and Steel Research Association, London, S.W.11

IT is now evident, from a variety of experiments, that under cyclic stresses metals may re-soften, if internal stresses already exist, or alternatively they may develop a process of hardening, if initially annealed. The softening resulting from cyclic stresses has been detected, for example, by compression and hardness[1,2], by creep[3] and by strain-cycling[4] measurements, the subsequent hardening being noted in creep[3] and also in hardness tests. In some cases both stages are observed in sequence.

The action of the fatigue stress is, then, two-fold. It first re-distributes and relieves internal stresses by the generation and movement of dislocations, and then builds up within the metal a state equivalent to one of reduced mobility of dislocations. The reason for this second effect is still largely conjectural, and several possibilities exist: for example, one promising line of thought couples it with the generation and aggregation of vacancies. Whatever the true physical mechanism may be, it is natural to assume that the hardening is related in some way to the development of a state of fatigue and as such its detection and measurement are of both theoretical and practical importance.

Unfortunately, from the more practical point of view, the character of this hardening process has so far shown no very useful features. A prediction of failure from such observations has not therefore been possible, even though microscopic cracks and markings may be observed very early on in the test. It is true that in the later stages, when these cracks are well developed, a change in the gross mechanical

* Present address: College of Aeronautics, Cranfield.

properties may be detected, but fatigue failure is then fairly imminent. The practical problem, then, is whether a potentially dangerous state of fatigue may be detected earlier in the life before the metal is heavily damaged. The experiments reported in this present communication are directly concerned with this question.

Experiments have been conducted on lead wires maintained at constant temperature in an apparatus which can apply a longitudinal fatigue stress (by an electromagnetic vibrator) or a torsional creep stress (by a galvanometer coil assembly) or both simultaneously. For convenience in the discussion, I shall designate the process of torsional creep when the fatigue stress is superimposed as 'fatigue-creep', and the similar process when the fatigue stress is absent as 'simple creep'.

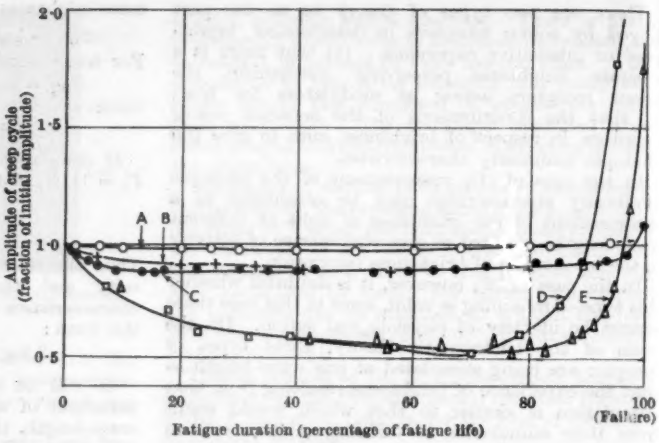

Fig. 1

The tests have been confined to very small ranges of strain, the maximum creep strains achieved being about 10^{-3}. The process is therefore referred to as one of microcreep, even though the strain is not fully recoverable at the test temperatures. If the temperature is low enough, say less than 150° C. for lead, then fatigue-creep may be fully recoverable when the creep stress is removed. Thus fatigue-creep can show one distinct difference from the simple creep behaviour in that it fully recovers on removal of the creep stress, whereas simple creep does not. Both forms of creep exhibit the usual type of transient creep curve, though fatigue-creep is far less regular. The superposition of the fatigue stress markedly increases the microcreep rate, of course, a property observed previously in the case of the more usual macrocreep.

Examination of the dependence of the creep-rate on temperature yields an activation energy for the microcreep process of about 19 kilocal./mole, which is the same as that derived for the macrocreep of lead[4], by a similar mathematical method. The dependence of the rate of fatigue-creep on temperature and frequency is, however, not simple, and peak effects are exhibited for certain conditions, similar in character to those obtained from measurements of damping capacity. It is important, therefore, to emphasize that a full description and analysis of the behaviour of the metal over ranges of frequency and temperature cannot be attempted in a short account such as this, and will be dealt with elsewhere when the work is published in full. The purpose of this present communication is simply to report those observations which have an immediate and direct bearing on the problem of detection of early fatigue damage.

Table 1. Details of the Tests shown in Fig. 1

Curve	Temp. (°C.)	Fatigue frequency (c./s.)	Fatigue stress (approx.) (kgm. cm.$^{-2}$)	Cycles to failure (millions)	Creep test conditions
A	150	285	10·0	8·55	Without fatigue superimposed (simple creep)
B	95	285	10·0	13·6	
C	125	285	12·5	28·2	
D	125	285	12·5	27·5	With fatigue superimposed (fatigue-creep)
E	110	285	5·0	44·8	

The basic creep test adopted was one in which the test piece was subjected to cycles of forward and reverse torsional creep, with a total cycle period of 40 min. The amplitude of this cycle may, for present purposes, be taken as a useful practical index of the overall creep behaviour. Obviously such cycles may be carried out under conditions of either simple creep or those of fatigue-creep at different stages in the fatigue life of a test-piece.

The results of five such tests are plotted in Fig. 1, the details being given in Table 1. The distinction between the simple creep and the fatigue-creep cases is interesting. For simple creep (cases *A*, *B* and *C*) the amplitude of the cycle falls at first to about 0·9 of its initial value (corresponding to a slight hardening) and then remains fairly constant until failure is imminent. On the other hand, fatigue-creep (represented by *D* and *E*) is much more sensitive to the development of the fatigue process. First, the amplitude of fatigue-creep falls very much more during the early stages of fatigue to a value of about 0·5 of the initial amplitude, and then, at about 0·7 of the fatigue life, it shows a rapid and distinctive re-softening. It has been checked that when fatigue-creep re-softening occurs in these test-pieces, the simple creep properties are similar to those given by curves *A*, *B* and *C*. The creep of the metal in this stage is, then, sensitive to combined creep and fatigue stresses, but not to creep stresses alone. This fact should provide an important pointer to the theories, particularly those concerned with the development and propagation of micro-cracks. Both curves *D* and *E* exhibit minima at about 9 million cycles before failure, so that in these cases an adequate warning of the onset of fatigue failure may be obtained.

A more general point of interest arising from these results is that other mechanical properties, for example, those of hardness, may offer similar criteria of damage if the tests are conducted with the fatigue stresses superimposed.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Moiré Patterns in Transmission Electron Micrographs of Sub-Boundaries of Aluminium

MOIRÉ patterns are interference fringes observed through two superposed, slightly misoriented diffraction gratings, or through two parallel gratings of slightly different spacing. When the misorientation between the gratings is very small the spacing of the moiré fringes may be much greater than the grating spacing. Mitsuishi, Nagasaki and Uyeda[1] observed that the lattice in thin sheets of crystal may act as gratings to produce moiré patterns in the electron microscope. More recently, Hashimoto and Uyeda[2] have shown that dislocations in these crystals are revealed as dislocations in the moiré patterns, and Pashley, Menter and Bassett[3] have recorded moiré patterns in specimens consisting of one metal epitaxially evaporated on to a single crystal film of another metal.

Hirsch[4] has shown that it is possible to observe individual dislocations directly in thin metal films by transmission electron microscopy. This technique is being used in this Laboratory[5] for studying specimens which include aluminium films beaten to a thickness of 2·5μ, annealed *in vacuo* at 350° C. and etched down to less than 1000 A. in 1 per cent hydrofluoric acid in water. These thin films are examined in transmission in an experimental prototype Metropolitan-Vickers *E.M.*6 operating at 70 kV. and at a magnification of 30,000.

In some of these films quite extensive areas of sub-boundaries may be seen and, as the misorientation is small at such boundaries, the conditions should be suitable for the formation of moiré fringes.

Fig. 1. Moiré fringes on a sub-boundary in aluminium. (× 150,000)

Such interference patterns have now been observed and an example is shown in Fig. 1. There is a much coarser extinction contour pattern in the same area. Individual dislocations are visible quite close to the boundary.

No dislocations have been found in the moiré patterns, though the dislocations which constitute the sub-boundaries are sometimes seen together with the moiré pattern. It appears, therefore, that the dislocations which form the sub-boundaries do not give rise to dislocations in the moiré pattern.

It is important to be able to assess the contribution of moiré patterns to electron micrographs of thin metal films studied in transmission. It also seems that useful information about the nature of sub-boundaries may be obtained by a study of moiré patterns, and further work is in progress on this aspect of the study of thin metal films.

Thanks are due to Mr. G. Rickards for his assistance with the electron microscopy and to Dr. T. E. Allibone for permission to publish this communication.

G. A. GEACH
R. PHILLIPS

Associated Electrical Industries, Ltd.,
Research Laboratory,
Aldermaston Court,
Aldermaston, Berkshire.

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Oxide Films on Silver at High Temperatures

IT is usually assumed that no oxide film can exist on the surface of metallic silver heated in air above 200° C., since bulk silver oxide, when heated in air, decomposes completely into silver and oxygen at this temperature[1]. Recent work in this laboratory has shown that this is not the case.

It is well known that mercury readily wets clean film-free solid metals but does not wet non-metallic surfaces—a fact demonstrated by Hoar and Farthing[2] during the electro-polishing of α-brass. This experiment has now been repeated for silver heated at various temperatures up to 800° C.

Two specimens, each 5 cm. × 1·8 cm. × 0·2 mm., of oxygen-free 99·99 per cent silver with a mirror finish were heated *in vacuo* to 450° C., and at this temperature hydrogen was introduced into the system for two periods of ten minutes, with an intervening evacuation. This was done in order to remove any initial film on the surface of the specimen. After the second hydrogen treatment, the system was again evacuated and the temperature raised to 800° C. Pure oxygen was then introduced at a

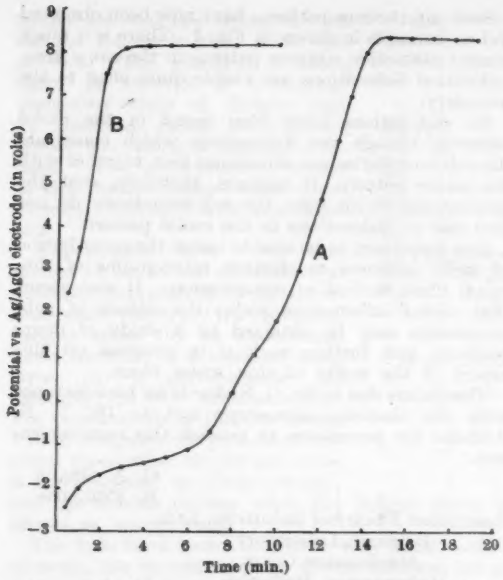

Fig. 1. Potential–time curves for (*A*) silver specimen oxidized at 800° C. for 1 hr., (*B*) oxidized specimen reduced in hydrogen at 450° C.

pressure of 72 cm. mercury and the silver specimens were kept in this atmosphere for 1 hr., after which the furnace was removed and the specimens were allowed a few minutes to cool to room temperature.

One of the specimens was taken out and a drop of mercury placed on it. It did not spread and its spherical shape was retained even after a period of two hours. The second specimen, which had been given identical treatment, was then heated to 450° C. in a vacuum, and at this temperature hydrogen was again introduced as previously described. The specimen was then cooled to room temperature and withdrawn from the apparatus. A drop of mercury was placed on the surface and there was instant spreading. The spreading became more pronounced with time, and in a few hours the whole surface was covered. The drop on the first specimen also spread with time, but at a much slower rate than that on the second.

These simple experiments show that an oxide film can exist on the surface of metallic silver heated in oxygen at 800° C., although no indication is given of the thickness of the film.

The electrometric method[3] was found suitable for measuring the film thickness, the apparatus being similar to that used by Mills and Evans[4] for copper. The oxidized specimen was suspended from a platinum hook and formed the cathode of the cell, with a silver – silver chloride anode. The electrolyte was a phosphate buffer (containing KH_2PO_4 and $Na_2HPO_4.12H_2O$) of *p*H 7·1, made up with twice-distilled water. A small amount of potassium chloride was added to the buffer so that a silver – silver chloride reference electrode could be used. The solution was de-aerated by alternately boiling under reduced pressure and then passing purified hydrogen into the apparatus. After four cycles, the electrolyte was forced by hydrogen pressure into the cell containing the specimen. The oxide film was then reduced by cathodic polarization with a current of 11 μamp. During the reduction, the potential of the specimen was measured against the silver – silver chloride electrode every 15 sec.

The potential–time curves for the two specimens are shown in Fig. 1. Curve *A*, obtained for the specimen oxidized at 800° C. for 1 hr., shows a well-defined plateau corresponding to the reduction of the oxide film, before the hydrogen-evolution potential is reached. The quantity of electricity consumed in the reduction of the silver oxide shows that the film is of the order of 5 A. in thickness, calculated on the apparent surface area and taking the density of the film as 7·14, the same as that of bulk silver oxide. Curve *B* is a typical curve for a specimen oxidized under the same conditions but afterwards reduced in hydrogen at 450° C. In this case there is no plateau and the hydrogen-evolution potential is reached almost immediately.

The electrometric method thus confirms the observation made with the mercury drops and is suitable for the determination of the thickness of the oxide film on silver.

D. Eurof Davies

Department of Metallurgy,
University College,
Singleton Park,
Swansea.
March 15.

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Radioactive Method for the Determination of Slag Mass during the Basic Open-Hearth Steel-making Process

In open-hearth steel-making, chemical reactions take place between the metal bath and a supernatant slag layer, and any material balance on the process demands an accurate knowledge of the masses involved. Metal mass varies only slightly throughout a heat and can be assessed with acceptable accuracy from the amount of steel produced. Slag mass, however, varies considerably throughout a heat, and there is a great need for a method of estimating it which has greater accuracy than the present methods based on a lime/magnesia or a phosphorus/manganese balance.

We have determined the slag mass at any chosen time by a radioactive method using the principle of adding a known activity to the slag and measuring the dilution in slag samples afterwards taken from the furnace.

Barium-140 in equilibrium with its daughter product lanthanum-140 was found to be the only radioactive tracer to satisfy the following necessary requirements:

(1) Its chemical form is such that it is distributed uniformly in the liquid slag without loss by partition to the metal or furnace walls, or by volatilization. Both parent and daughter isotopes (as oxides or carbonates) fulfil this condition.

(2) The emitted radiation is easily measurable, the characteristics being:

Isotope	Half-life	Mode of decay
Barium-140	12·8 days	Beta emission to lanthanum-140 with emission of gamma photons up to 0·54 MeV.
Lanthanum-140	40·2 hr.	Beta emission to cerium-140 with emission of gamma photons up to 2·57 MeV.

In practice, for reasons relating to counting techniques, only the high-energy radiation of lanthanum-140 is measured.

(3) No health hazards are introduced by the isotope being used in too great a quantity or having a long radioactive and biological half-life. On the other hand, the radioactive half-life is sufficient to permit measurements to be taken.

(4) It is readily available free from other radioactive contamination.

Lanthanum-140 alone could be used instead of the combination; but the short half-life and difficulties in preparation for this purpose make it much less practicable. The adoption of barium-140 effectively provides the best characteristics of both radio-elements, namely, the higher energy of the lanthanum-140 radiation together with the more useful half-life of the barium-140.

Careful procedures have been established for adding the isotope to the furnace, taking and preparing the slag samples, and for diluting in the laboratory a standard sample from the same batch of barium-140.

Measurements to date have been carried out in furnaces of steel capacity ranging from about 80 to 350 tons and carrying from about 8 to 40 tons of slag. The barium-140 additions have ranged from about 2 to 12 mc., the amount being calculated to produce a slag activity of the order of 0·1 μc./lb. This level does not give rise to radiation or ingestion hazards—it would be necessary to eat several pounds of slag to obtain an undesirable level of activity inside the body.

Lack of an accurate alternative method makes it difficult to check the radioactive technique; but, with the co-operation of the melting shop staff of Appleby-Frodingham Steel Co., elaborate arrangements were made to weigh directly the slag from a 350-ton tilting furnace. This included careful crushing of the whole of the slag for magnetic removal of entrapped steel prior to actual physical weighing. Considering the practical difficulties of these operations, the comparative figures obtained were remarkably close:

Mass by direct weighing	31·4, tons
Mass by radioactive method	31·6, tons

Successful measurements have now been made on some 150 different casts and the consistency of results indicates an overall accuracy of about ± 1 per cent.

This work has been carried out by the Research and Development Department of the United Steel Companies, Ltd., in co-operation with the steel-making branches. Grateful acknowledgment is made to Mr. F. H. Saniter, director of research, for permission to publish this communication. It is intended to publish later full details of the principles and the practical techniques involved.

G. R. Church
W. C. Heselwood
G. A. Nicholson

The United Steel Companies, Ltd.,
Research and Development Department,
Swinden Laboratories,
Moorgate,
Rotherham.

April 29.

Grüneisen's Rule and the Thermal Expansion of Metals

Grüneisen[1] arrived at an empirical rule connecting the volume expansion of solids due to rise in temperature with the atomic heat of the solid and its compressibility at absolute zero. This rule has been stated in various forms, and Hume-Rothery[2], after a comparative study of the various forms, has recommended the form due to Simon and Vohsen[3], namely:

$$\frac{T_T - V_0}{V_0} = \frac{E_T}{Q - KE_T}$$

where V_T and V_0 are the volumes of the solid at $T°$ K. and 0° K. respectively, E_T is the total heat content of the solid at $T°$ K. and Q and K are constants. Thus

$$\frac{V_0}{V_T - V_0} = \frac{Q}{E_T} - K \qquad (1)$$

$\frac{V_T - V_0}{V_0}$ may be substituted by $3\,\frac{a_T - a_0}{a_0}$, where a_T and a_0 are lattice parameters of a cubic crystal at $T°$ K. and 0° K., respectively. Similarly, we may write for E_T the Debye expression $9\,RTD\,(\theta/T)$. Substituting these values in equation 1, it becomes evident that the curve of $\frac{a_0}{a_T - a_0}$ vs. $\frac{1}{TD\,(\theta/T)}$ will become a straight line. Fischmeister[4] has drawn these curves for ionic crystals such as sodium and potassium chlorides, potassium and cæsium bromides, potassium and cæsium iodides and lithium fluoride, and in each of these cases has obtained a straight-line curve. The present work was undertaken to find out if the same linear relation is obeyed for pure metals. For this purpose, the cell edges of pure copper, aluminium, silver and platinum at various temperatures were studied by the X-ray diffraction method. Measurements were carried out

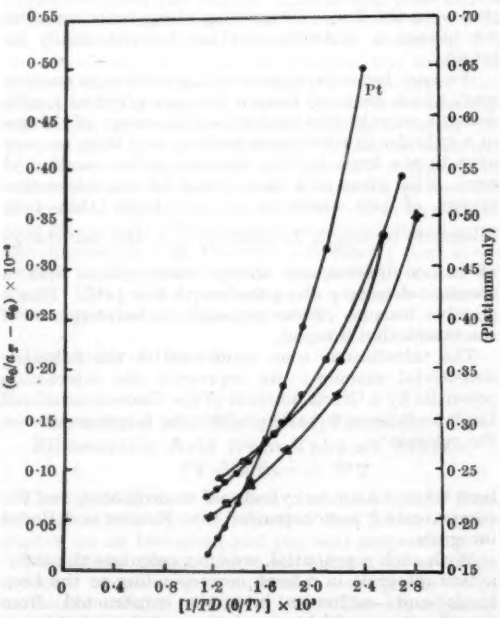

Fig. 1. Curve Pt refers to platinum; ●—●, silver; ▽○—○, copper; ◇—◇, aluminium

with the help of a 19-cm. camera and filtered X-rays were used. The cell edges were determined by the extrapolation technique due to Sinclair and Taylor[5]. Extrapolation to absolute zero was carried out by the technique described by Fischmeister[4]. The resultant curves are shown in Fig. 1. Unlike the curves for ionic crystals obtained by Fischmeister[4] for metallic crystals, these are non-linear. Further work is being carried out to find the nature of these curves for other metals and alloys.

Thanks are due to Prof. K. Banerjee and Prof. S. Gupta for their interest in the work.

G. B. Mitra
S. K. Mitra

Department of Physics,
Indian Institute of Technology,
Kharagpur, India.
March 8.

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Interaction Energy of Electric Charges in a Very Thin Tube

In classical electrostatics, we have the problem of the mutual interaction of two electric charges in a one-dimensional linear space, or—a similar problem—the self-energy of a one-dimensional continuous distribution of charge. Treatment of these problems thus far has given the well-known result that the energy of both these interactions is infinite.

It has been assumed *a priori* that the potential due to the interaction for two points and corresponding to the above distribution is of the type $\frac{1}{|z_1 - z_2|}$, where z_1 and z_2 are the co-ordinates of points on the line. Integrating along both variables we obtain a quantity tending logarithmically to infinity.

We may, however, approach this problem in another way, which seems to have a stronger physical justification: we calculate the interaction energy of charges in a cylinder of finite cross-section, and then we pass over to the limit for the cylinder radius tending to zero. This gives us a finite value for the interaction energy of two electrons in an ideally thin tube (filament) of length L, namely, $\frac{e^2}{L}$; the self-energy of a one-dimensional charge distribution with a constant density ρ along the length L is $\frac{1}{2}\rho^2 L$. This is possible because of the non-uniform convergence of the interaction integral.

The calculations were conducted in the following non-trivial manner: we represent the interaction potential by a Green function of the three-dimensional Laplace–Poisson equation, where the function satisfies the relation[1]

$$\nabla^2 G = -\delta(\mathbf{r} - \mathbf{r}')$$

here ∇^2 and δ are in cylindrical co-ordinates, and the components δ were expanded into Fourier and Bessel integrals.

With such a potential, we next calculate the interaction integrals in a form corresponding to the Coulomb and exchange integrals constructed from eigenfunctions which are solutions of the Schrödinger equation for particles moving freely in a cylindrical box of length L and radius R. In this way we obtain, in the limit, an integral for those parameters of the eigenfunctions which correspond to the interaction energy of the classical problem; finally, we obtain the value of this integral for R tending to zero.

The above problem was studied because of its relation to the interaction of electrons in the free-electron model of conjugated organic molecules, this interaction being of basic importance when that model is used for explaining the structure of the absorption spectra of these compounds.

S. Olszewski

Institute of Physical Chemistry,
Polish Academy of Sciences,
Warsaw. March 19.

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Irreversible Processes in Physical Theory

In two recent communications[1], Prof. K. R. Popper has emphasized the existence of physical processes the irreversibility of which is attributable to the physical impossibility of the initial conditions requisite to the occurrence of their inverses, apart from any relationship to thermodynamic theory. Popper refers to an earlier argument of the same type by Einstein[2]. We believe that his point is a sound one and deserves formulation as a general principle.

We distinguish two types of systems which we call 'closed' and 'open'. In classical mechanics the closed systems have quasi-periodic orbits, whereas the open systems have at least some aperiodic orbits which extend to infinity. In quantum mechanics the closed systems have totally discrete energy spectra, whereas the open systems have continuous spectra[3]. It is sufficient for present purposes to think of a closed system as one confined in a region of finite volume by an outer wall, whereas an open system has no such outer boundary. The theoretical reversibility of elementary processes in both closed and open systems is guaranteed formally in both classical and quantum mechanics by the equations of motion themselves, provided that the maximum information permitted by the theory is supplied.

But there exists a fundamental distinction between the two kinds of system in the following sense. In open systems there always exists a class of allowed elementary processes the inverses of which are unacceptable on physical grounds by requiring a *deus ex machina* for their production. For example, in an open universe, matter or radiation can travel away indefinitely from the 'finite' region of space, and so be permanently lost. The inverse process would require matter or radiant energy coming from 'infinity', and so would involve a process which is not realizable by physical sources. Einstein's example of an outgoing light wave and Popper's analogous case of a water wave are special finite illustrations of this principle.

Einstein argues further that on the emission theory of electromagnetism, as opposed to the wave theory, the energy imparted to a photon on emission is not scattered over infinite space but remains available for elementary processes of absorption and scattering, and he seems to imply by this that the photon theory allows a type of reversibility which is denied to the wave theory. There is no reason, however, for favouring either form of radiation theory on the grounds of reversibility alone, since both forms of emission pro-

cess would be irreversible under the conditions of our principle.

The theory sketched above, which depends on the topological character of the state space of a physical system, is logically independent of the statistical assumptions on which the concept of entropy is based. Although the latter concept is pertinent to a partial characterization of the empirical and psychological basis of time's arrow in our ordinary physical environment[4], it has no intrinsic relevance, in our view, to physical irreversibility as such. The non-entropic irreversibility of open systems not only contributes to time's arrow on the cosmic scale, but can also be seen to play a part in the anisotropy of the time of our ordinary environment. If a finite system A is chosen, but is allowed to interact with 'the rest of the universe', the behaviour of A will be that of an open system for ordinary intervals of time. Thus the irreversibility formulated in the principle we have stated as a generalization of Einstein's and Popper's examples enters 'locally' into time's arrow, unlike the irreversibility of a purely cosmological process such as the speculative monotone increase of the radius of spherical space.

One of us (A. G.) is indebted to the National Science Foundation for the support of research.

E. L. Hill
A. Grünbaum*

School of Physics,
and
Minnesota Center for Philosophy of Science,
University of Minnesota,
Minneapolis, Minn.

* Present address: Lehigh University, Bethlehem, Pennsylvania, U.S.A.

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The support given by Profs. Hill and Grünbaum in their interesting communication is very encouraging. The problem before us—before these two authors as well as before myself—is the clarification of the notion of a 'causally irreversible physical process'; or more precisely, of a process that is (*a*) 'theoretically reversible', in the sense that physical theory allows us to specify conditions which would reverse the process, and at the same time (*b*) 'causally irreversible', in the sense that it is causally impossible to realize the required conditions. Everything depends here upon making clear what we mean by saying that it is 'causally impossible to realize certain conditions'.

In this connexion, I must express some doubt as to whether the principle proposed by Profs. Hill and Grünbaum is adequate. In formulating their principle, they operate with two ideas: that of the 'openness' of a system, and that of a *deus ex machina*. Both seem to me insufficient. For a system consisting of a sun, and a comet coming from infinity and describing a hyperbolic path around the sun, seems to me to satisfy all the criteria stated by them. The system is open; and the reversion of the comet on its track would require a *deus ex machina* for its realization: it would "require matter . . . coming from 'infinity' ". Nevertheless, this is an example of just that kind of process which, I take it, we all wish to describe as completely reversible.

On the other hand, compare the following two closed systems: (i) A cavity, of the shape of an ellipse rotated around its major axis, with walls that are perfect mirrors, and two atoms in the two foci. Here the emission of light by one atom will lead to its absorption and re-emission by the other, and so on, *ad infinitum*. The process is, clearly, reversible. (ii) A closed room, with an electric bulb in it, and straight walls but slightly rough and painted white. (We assume that the system is closed so that no heat escapes.) Now in the classical theory, this case is theoretically reversible: we have only to reverse the movement of all the oscillators in the surface of the walls, and the light will return to the bulb which will absorb it, thereby getting hot. At the same time, the process is 'causally irreversible'. The reason is (as mentioned in my previous communications) the problem of *coherence*. We know that (distant) oscillators can be induced to emit coherent light only by exciting them from a central source of light. Causally unconnected oscillators can never be made to cohere; and the attempt to relate them causally, and to obtain coherence, would bring us back to a case like (*i*).

The impossibility here mentioned is clearly different from that of returning a hyperbolic comet in its path: for this we merely need a *deus ex machina* who is something like a gigantic tennis player—the affair can be directed from one centre. But this is essentially not the case if we try to make light waves return, or water waves; not even in the classical theory.

Although I cannot quite subscribe to Profs. Hill and Grünbaum's interpretation of Einstein's remarks, it is clear, I think, that my argument conforms to their suggestion that we should not favour either form of radiation theory.

The point of my argument is merely this. Only such conditions can be causally realized as can be organized from one centre. The feeling that this is so may have contributed to Newton's doctrine that all forces are 'central forces'. Yet although this theory turned out to be too narrow, the theory of 'central causes' seems to me correct in the sense that causes which are not centrally correlated are causally unrelated, and can co-operate only by accident (or by a miracle). The probability of such an accident will be zero; and whatever exists of a theory of coherence tells us that we can do nothing to increase this probability. However, I do not wish to suggest that all causally irreversible processes are based upon the impossibility of reversing coherence; and I am unable to offer a solution to the problem, raised by Profs. Hill and Grünbaum, of giving a general characterization of these processes.

K. R. Popper

University of London.

Structure and Biological Function of Ribonucleic Acid from Tobacco Mosaic Virus

The finding that isolated ribonucleic acid from tobacco mosaic virus is infective[1] has led to further studies on its biological and physical properties.

The whole ribonucleic acid content of a single tobacco mosaic virus molecule corresponds to a molecular weight of $2\text{–}3 \times 10^6$. The experiments to be described suggest that the biological activity depends on the integrity of this core.

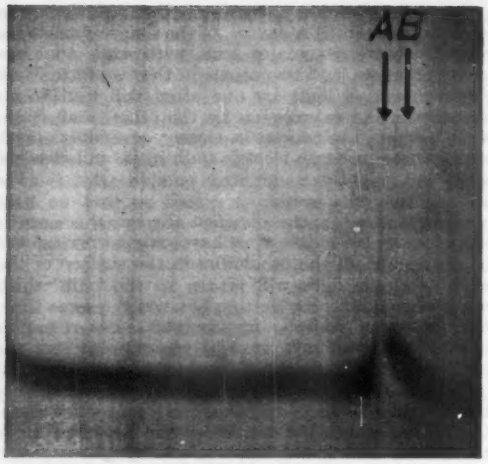

Fig. 1. Sedimentation diagram of 0·24 per cent ribonucleic acid in 0·02 *M* phosphate buffer, *p*H 7 at 5° C., 50,000 rev./min. Peak *A*, homogeneous component; *B*, slower migrating, poly-disperse component. The sedimentation constant of component *A* is 19 *S* at this concentration

Ribonucleic acid prepared by the phenol method[1] contains a component (*A*) which is homogeneous in the sedimentation diagram (Fig. 1). In addition, there are slower migrating, seemingly degraded components (*B*). The mean molecular weight[2] of the ribonucleic acid is around 10^6. In order to obtain the molecular weight of component *A*, the sedimentation constant, the intrinsic viscosity, and the corresponding mean molecular weight have been studied with the ribonucleic acid in the original state and in various states of degradation. In this way, a relation between molecular weight and sedimentation constant was found and led to a value of about $2 \cdot 1 \times 10^6$ for the homogeneous component *A*, corresponding within the limits of accuracy to the intact ribonucleic acid core.

The sedimentation constant of the infective component is the same as that of component *A* within ± 25 per cent. This was determined by differential ultracentrifugation followed by testing the specific infectivity of the ribonucleic acid in the supernatant. The molecular weight of the infective component is thus about $2 \cdot 1 \times 10^6$.

The molecular weight of the smallest infective units can be obtained by studying the correlation between the decrease in mean molecular weight (weight average m) and infectivity L in the course of degradation by ribonuclease. Control experiments revealed that m is nearly proportional to the intrinsic viscosity $[\eta]$, and L to the counts of lesions on *Nicotiana glutinosa*. A typical example of the measured decrease in infectivity, viscosity and mean molecular weight is given in Table 1. The decrease in L is much faster than that in m. This indicates that the molecular weight of the infective component (M) is larger than m. A quantitative correlation can be derived to calculate M:

$$\frac{1}{m_1} - \frac{1}{m_2} = \frac{1}{2M} (\ln L_1 - \ln L_2)$$

The values given in Table 1 lead to $M = 2 \cdot 2 \times 10^6$, whereas the mean value from all measurements of this type is $2 \cdot 5 \times 10^6$.

Table 1. Decrease of intrinsic viscosity, $[\eta]$, mean molecular weight (weight average) m, and infectivity, L, with time. The decrease was induced by $1 \cdot 5 \times 10^{-3}$ µgm./ml. ribonuclease at 22° C. in a solution of 0·16 per cent ribonucleic acid in 0·02 *M* phosphate buffer, *p*H 7. The infectivity, L, is given as the number of lesions per 25 leaves of *Nicotiana glutinosa* inoculated with 20 µgm./ml. ribonucleic acid in 0·1 *M* phosphate

t (min.)	$[\eta]$ (c.c./gm.)	m	L (lesions)
0	300	$1 \cdot 20 \times 10^6$	980
5	274	$1 \cdot 10 \times 10^6$	786
11	254	$1 \cdot 02 \times 10^6$	383
17	232	$0 \cdot 93 \times 10^6$	487
22	214	$0 \cdot 86 \times 10^6$	272
28	196	$0 \cdot 78 \times 10^6$	242
37	168	$0 \cdot 67 \times 10^6$	62
65	115	$0 \cdot 46 \times 10^6$	1

When the infective unit has received an average of one break of an internucleotide bond through the action of ribonuclease, the infectivity is expected to be reduced by a factor e. The molecular weight can be calculated if the activity of the enzyme, given as the proportion of bonds split per unit of enzyme concentration and time, is measured under the conditions used for the infectivity test. This was done in two steps. First, it was estimated by titration that a state of degradation corresponding to one break per molecular weight of 7,000 is indicated by an increase in the ultra-violet absorption at 260 mµ by 15 per cent. Then it was found that this state is reached by 260 times the enzymatic action which reduces the infectivity by the factor e. Therefore, the molecular weight of the active unit is about $260 \times 7{,}000 = 1 \cdot 8 \times 10^6$.

Thus, within the limited accuracy of the determinations described, different approaches lead to the same size of 2×10^6 for the infective unit, corresponding approximately to the entire ribonucleic acid core of a tobacco mosaic virus molecule. Smaller fragments obtained by the action of ribonuclease are inactive. Parts necessary for infection must therefore be distributed along a large part of the ribonucleic acid core. Sections without biological functions in between are not excluded. If small active sub-units exist, they might form strands wound parallel around each other to make up the ribonucleic acid core. A structure of this type, however, is not likely in view of the following evidence.

With respect to the structure of the ribonucleic acid in solution, the following observations are relevant.

(1) The intrinsic viscosity of the ribonucleic acid is found to be proportional to approximately the first power of its mean molecular weight, suggesting a structure intermediate between a random coil and a stiff rod. The whole core appears as a flexible, moderately coiled chain with dimensions of several thousand angstroms.

(2) Ribonucleic acid of high molecular weight has a large optical rotation ($\alpha = 220°$ at 546 mµ) as compared with that of degraded ribonucleic acid ($\alpha < 30°$), whereas the ultra-violet absorption at 260 mµ is less for larger molecules than for smaller ones. The minimum molecular weight for high rotation and low absorption is about 7,000, corresponding to twenty nucleotides. This is evidence in favour of a superstructure of the larger molecules of ribonucleic acid in solution.

(3) Ribonuclease causes a breakdown of the ribonucleic acid that proceeds without a lag phase (Table 1), indicating that single splitting processes determine the rate.

(4) From the absolute activity of the ribonuclease and the induced reduction in the mean molecular weight of ribonucleic acid, it is estimated that any, or nearly any, break of an internucleotide bond causes a molecule to disintegrate.

If the structure should consist of several strands (3) and (4) would imply that splits within different strands are not independent. This being unlikely, the ribonucleic acid is more probably single-stranded. A simple model for a single-stranded superstructure would be a helix with hydrogen bonds between nucleotides of adjacent turns.

A detailed account of this work will be published elsewhere. I am much indebted to Prof. G. Schramm and Prof. H. Friedrich-Freksa for support and advice and to Miss A. Kleih and Mr. W. Mönch for assistance.

ALFRED GIERER

Max-Planck-Institut für Virusforschung,
Tübingen.
April 12.

[1] Gierer, A., and Schramm, G., *Nature*, **177**, 702 (1956); *Z. f. Naturforsch.*, **11b**, 138 (1956).
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Utilization of Carbohydrates by the Young Calf

IN recent years, increasing attention has been paid to early weaning and rearing of young calves and pigs away from their dams on diets other than whole milk. A variety of such milk replacement diets is now available, though many of them contain a large proportion of milk products such as dried skim milk or dried whey. From a practical point of view, the use of cheaper starch-containing foods is very attractive, and reasonable results have been obtained with 4-week old calves given combinations of skim milk and oat flour.

We found here that calves up to three weeks of age did badly on a skim milk diet containing as the main source of energy oat flour or flaked maize predigested with preparations of α- or β-amylase, alone or in conjunction[1].

Chromatographic examination of the products of such digestion showed that the main product was maltose, together with some dextrins and a little glucose. It seemed probable, therefore, that the young calf was unable to utilize maltose or dextrins, and direct evidence was sought by following the changes in the concentration of reducing sugars in the blood after a test meal.

Eight new-born calves reared for two days on colostrum and thereafter on whole milk were used. They were muzzled to prevent access to roughage. At intervals of a few days the animals were fasted overnight and received then by mouth solutions in water of glucose, lactose, sucrose, maltose, dextrin or soluble starch at the rate of 2 gm. of carbohydrate per lb. body-weight. The concentration of reducing sugars in the jugular blood determined by the method of Somogyi[2] was followed for the ensuing 5 hr.

The results show clearly that during the first four weeks of life the non-ruminant calf utilized, of the carbohydrates tested, only glucose or lactose. However, at nine weeks we found appreciable utilization of maltose which earlier workers showed to be well utilized at nine months[3]. Values for soluble starch and dextrin are not given in Fig. 1, but as expected they were not used at all.

Preliminary examination of the amylolytic activity of the pancreas and of the maltase, lactase and sucrase activities of extracts of intestinal mucosa of young calves showed excellent correlation with the blood-sugar findings: lactase activity was high in the very young animal, but that of amylase or maltase was very low; the activity of amylase and maltase increased with age while that of lactase decreased; no sucrase activity was detected.

It is clear, therefore, that of those tested lactose and glucose are the only available carbohydrate components of diets suitable for calves during the pre-ruminant period of life, and that cereal flours, either raw, dextrinized or cooked (as in flaked maize), serve no useful purpose as sources of energy until rumen function begins. Once the microbial flora of the rumen becomes established bacterial enzymes break down starch to substances that can be utilized by the host. Furthermore, it follows from our findings that predigestion of cereal starches by amylase must be complemented by the action of maltase to carry the degradation to glucose.

Early reports, based on digestibility studies, that the young calf can utilize starch[4] are clearly misleading as they ignore the contribution of the bacterial flora of the large gut to the degradation of carbohydrate—a process that does not necessarily contribute to the nutrition of the host.

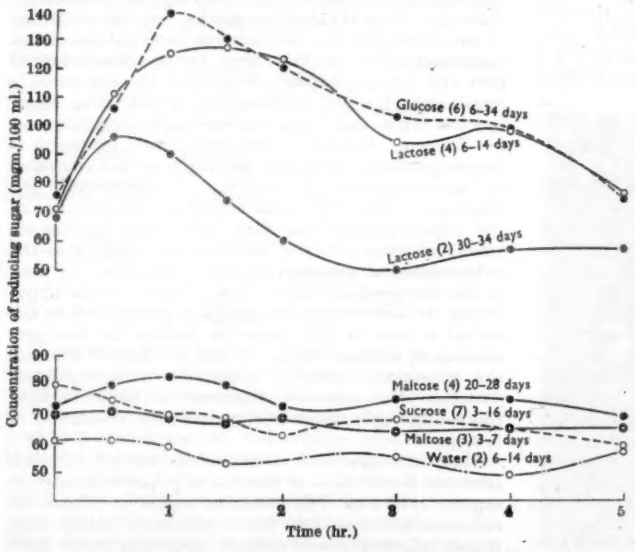
Concentration of reducing sugar (mgm./100 ml.)
Time (hr.)
Glucose (6) 6–34 days
Lactose (4) 6–14 days
Lactose (2) 30–34 days
Maltose (4) 20–28 days
Sucrose (7) 3–16 days
Maltose (3) 3–7 days
Water (2) 6–14 days

Fig. 1. Concentrations of reducing sugars (mgm./100 ml.) in the blood of calves given by mouth various carbohydrates at the rate of 2 gm./lb. body weight. Mean values for stated numbers (in parentheses) at given ages

We hope to report elsewhere these findings and those of similar studies with the young pig and chick now in progress.

A. M. Dollar
J. W. G. Porter

National Institute for Research in Dairying,
University of Reading.
March 12.

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Artificial Activation of the Egg in a Gynogenetic Spider Beetle

In a recent communication in *Nature* by Moore, Woodroffe and Sanderson[1], it was shown that the spider beetle *Ptinus latro* Fab. exists only as females and that these require to be inseminated by males of the allied *Ptinus hirtellus* Sturm in order to produce viable eggs. Insemination by sterilized males was ineffective. The details of the cytological phenomena involved were communicated at the Tenth International Congress of Entomology, 1956[2]. Since no conclusions could be reached as to whether the sperm enters the yolk of the *P. latro* egg, it is proposed to carry out experiments using labelled sperm and autoradiography. Meanwhile, the following is a report on results of experiments on artificial activation of the virgin egg. The methods employed involved cold and heat treatments, exposure to ether vapour, and puncturing with a fine glass needle, but the best results were obtained with the needle puncture method or traumatization. It was found that the maturation division proceeded as far as telophase (Fig. 1) in 50–60 per cent of the 200 eggs treated. Eggs were squashed in aceto-orcein from 10 to 120 min. after puncture and it was observed that the maturation division is complete usually after 30 min. However, no onset of cleavage was seen up to 2 hr., after which time the eggs tend to dry up. In untreated eggs from virgin females, the development is usually blocked at the first metaphase (Fig. 2). The chromosomes may remain in this stage up to a period of five days, and then degenerate. From the remarkably high percentage of eggs activated by traumatization, it seems reasonable to assume that the role of the sperm in initiating activation is mainly of a physical nature. Further work is in progress and will be reported elsewhere.

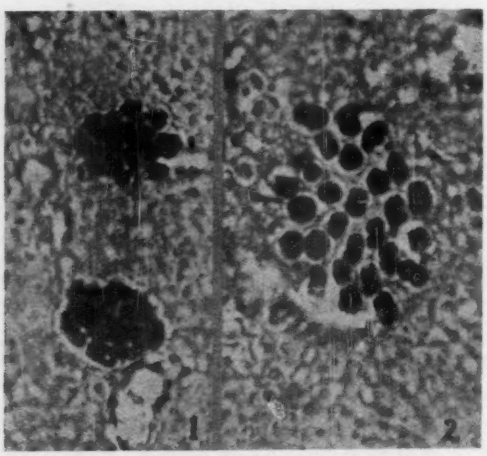

Fig. 1. Telophase of maturation division in an activated egg
Fig. 2. Arrested metaphase in an 'unfertilized' egg

The low percentage of viable eggs produced by mated *P. latro* calls for some comment. The fact that large numbers of sperms can be seen adhering to the chorion of eggs from inseminated females suggests an inability on the part of the female to regulate the flow of sperms, with consequent rapid depletion of the supply and non-activation of the later-laid eggs. The presence of the spermatheca and the necessity for activation by sperms suggest that parthenogenesis in this beetle is of recent origin.

We are grateful to Mr. G. E. Woodroffe, of the Pest Infestation Laboratory, Slough, for the generous supply of specimens and relevant information regarding their culture. One of us (J. J.) is the holder of a Science Research Scholarship (Overseas) of the Royal Commission for the Exhibition of 1851.

Ann R. Sanderson
J. Jacob

Natural History Department,
Queen's College,
University of St. Andrews,
Dundee.
March 15.

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The Diapause Hormone of the Silkworm, *Bombyx mori*

In 1924, Watanabe[1] postulated that silkworm eggs overwinter as a result of receiving an 'inhibitory' substance from the mother moths, but the existence of the substance has not hitherto been substantiated experimentally. On the other hand, I have found[2] that the subœsophageal ganglion of the silkworm is responsible for the hibernation of silkworm eggs; but the organ that furnishes the active principle was not known. Evidently diapause of the silkworm is controlled by a hormone, similarly to the moulting or metamorphosis of insects. I attributed[2] the diapause of silkworm eggs solely to the function of the subœsophageal ganglion, the brain having no effect, whereas Fukuda[4] ascribed the activity of the subœsophageal ganglion to brain regulation by way of the œsophageal connectives. Thus in both hypotheses the subœsophageal ganglion is regarded as the actual source of the principle leading to the production of diapause eggs. It was not known whether the substance secreted from the subœsophageal ganglion—the diapause hormone—is identical with the inhibitory substance suggested by Watanabe or not.

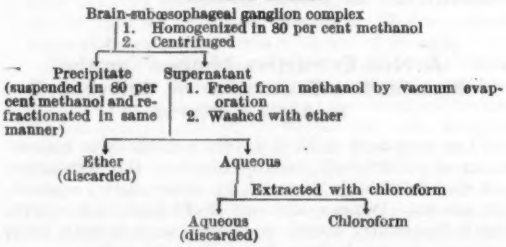
Many attempts have been made to extract diapause hormone from blood or ovaries of pupæ with various organic solvents. The ganglion begins to release the diapause hormone into the blood immediately after pupation[3], and the ovaries of silkworm pupæ grow most rapidly at the middle pupal stage[5]. Furthermore, it was considered that the subœsophageal ganglion

would not accumulate the hormone, but would liberate the hormone into the blood continuously, thus passing it to the ovaries in the pupæ; in other words, blood or ovaries were regarded as materials suitable for extraction of the hormone. It is now seen that one of the chief reasons for the lack of success was because blood or ovaries were used as starting materials.

When silkworm pupæ were injected with a concentrated extract from blood or ovaries, they failed to develop, whereas the pupæ injected with a diluted extract transformed into moths without any change in their own eggs and laid normal non-hibernating eggs. So the possibility of the extraction of the hormone remained uncertain. Among the many moths thus tested during the past three years, only an occasional individual laid hibernating eggs as if an extract had exerted its effect, that is, the moths laid both hibernating eggs and non-hibernating ones. Thus the appearance of hibernating eggs seemed to depend on some disturbed metabolism of the pupæ caused by injection of the extract itself. The blood or ovaries of pupæ presumably do not contain the hormone in sufficient quantity for extraction.

Recent work, however, has demonstrated the possibility of extracting the diapause hormone in the subœsophageal ganglion of pupæ. In 1956, the first isolation of this hormone was achieved by treating the brain–subœsophageal ganglion complex of about 15,000 pupæ with methanol, ether and finally chloroform as outlined in the accompanying scheme. After evaporation of chloroform, the residue showed high potency of diapause hormone as tested by the injection method, the solution to be injected being made by adding the extract to 1·6 c.c. of distilled water. Injection of 0·02–0·04 c.c. of the solution into a pupa to produce non-hibernating eggs duplicated the results obtained by the implantation of active subœsophageal ganglion; that is, the eggs laid by the resultant moths began to form pigment in their serosa cells, following which the pigmentation proceeded to completion of the proper colour of hibernating eggs of the race. The extract exerted its effect upon pure polyvoltine races, and made their non-hibernating eggs hibernate as well.

PROCEDURE USED TO SEPARATE THE DIAPAUSE HORMONE FROM GANGLION TISSUES



Karlson[6] used the heads of female silkworm moths as well as those of male pupæ as materials for extraction of the corpus allatum hormone. He obtained an ether extract which inhibited the development of post-diapause pupæ of Saturniidae and suggested that this extract may contain the diapause hormone of the subœsophageal ganglion. In the addendum of his paper, however, he admitted that the observation was probably an experimental mistake. The ether extract does not contain the diapause hormone, because the hormone isolated by me from the brain–subœsophageal ganglion complex of pupæ resists extraction with pure ether, and the ether extract from the complex has no power to make non-hibernating eggs hibernate. Karlson's extract may be a substance similar to the corpus allatum hormone, as the latter can be extracted with ether[7].

From further studies on this subject by employing heads of silkworm moths as the source of diapause hormone, I have also separated the active part showing the same solubility in various solvents and the same stability to certain temperatures as the hormone extract of the brain–subœsophageal ganglion complex of pupæ; those will be discussed elsewhere.

With the collaboration of Profs. Y. Hirata and K. Nakanisi (Department of Chemistry, Faculty of Science, Nagoya University) the purification of the diapause hormone is now being attempted.

KINSAKU HASEGAWA

Sericultural Laboratory,
Faculty of Agriculture,
Nagoya University,
Anzyo, Aiti-ken, Japan.

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Effect of Temperature and Hydrogen-Ion Concentration on the Germination of Spores of *Bacillus cereus*

Of the factors influencing spore germination, the effects of temperature and of hydrogen-ion concentration were studied by Powell's method[1], which registers the first apparent changes of germination, namely, the loss of refractivity, by measuring the turbidity of fairly dense spore suspensions.

The germination medium was prepared by two-fold dilution of a stock solution consisting of 4 gm. meat extract, 200 ml. sweet whey, 100 ml. of a (1 + 10) yeast decoction, 10 gm. glucose, 5 gm. peptone, 6 gm. potassium dihydrogen phosphate and 700 ml. water, sterilized at 115° C. for 30 min. In the experiments on the effect of *p*H, the dilution water contained the necessary amount of acid to establish the *p*H-level required (usually the following *p*H values: 4·00, 4·25, 4·75, 5·00 and 6·00). The *p*H of the control, not containing added acid, was 7·0.

Turbidity of the suspensions in test-tubes was measured in a Lange-type photoelectric colorimeter using a specially designed tube adapter. Suspensions containing about 4×10^8/ml. spores of a strain of *Bacillus cereus* were ordinarily prepared, using five parallel tubes for each treatment. The test-tubes were immersed in an electrically heated water-bath regulated to about $\pm$ 0·25° C. Turbidity readings were recorded (as a percentage of light absorption) every 3 or 6 min. in the first hour, and every 15 or 30 min. in the next three hours. From these observations turbidity reduction curves were drawn for every test-tube and the velocity of the process, called 'germination velocity', as well as the 'extent of germination' evaluated graphically. As a measure of germination velocity, the k value was calculated from the time t (in min.) necessary to reduce turbidity to 20 per cent (by extrapolation) of its original value, k being equal to $100/t$. The extent of germination,

G, was computed from M, expressing absorption at the lowest portion of the turbidity curve as percentage of the original absorption. The formula for G was: $100\ (100-M_0)/(100-M_c)$, M_0 indicating the mean of the five parallel test-tubes in question and M_c that of the controls. Results for M_0 at 30° C. served as controls in the experiments on temperature, and those obtained at *p*H 7·0 served as controls for the experiments on *p*H.

Varying the temperature of incubation between 15° and 45° C. at two different *p*H-levels gave the results shown in Table 1.

Table 1

Temperature (° C.)	Germination velocity (k) (means of 5 parallel tubes)		Extent of germination (G)	
	*p*H = 5·1	*p*H = 7·0	*p*H = 5·1	*p*H = 7·0
15	0·84	1·26	80·5	76·5
20	2·70	4·03	92·9	96·8
25	2·90	6·26	71·7	93·2
30	3·51	12·36	68·1	100·0
35	4·58	19·58	53·4	94·9
40	0·88	39·77	19·1	98·0
45	0	15·88	0	88·9

As may be seen from Table 1, the effect of changes in temperature differs markedly at the two *p*H-levels employed. Whereas at *p*H 7·0 germination velocity shows big changes with temperature, at *p*H 5·1 it is apparently uninfluenced by the latter. As regards extent of germination, however, no substantial changes occur at *p*H 7·0, but there is a strong dependence on temperature at *p*H 5·1. Application of the usual Arrhenius plot to k values, determined at *p*H 7·0 and temperatures between 20° and 40° C., resulted in a temperature characteristic (μ) of 21,000, and a temperature coefficient (Q_{10}) of 3·1. The optimum was found to be around 40° C.

The *p*H of the germination medium was varied, at 20° C., between 4 and 6 by the addition of different inorganic and organic acids. As may be seen from Figs. 1 and 2, germination velocity and extent of germination mainly depended upon hydrogen-ion concentration and were independent of the nature of the acid, at least in the case of hydrochloric, phosphoric, tartaric, citric and lactic acids. With acetic acid, however, a special inhibitory effect was observed. Virtually complete inhibition took place at *p*H 4·5 with acetic acid, but only at *p*H 4·0 with the other acids tested.

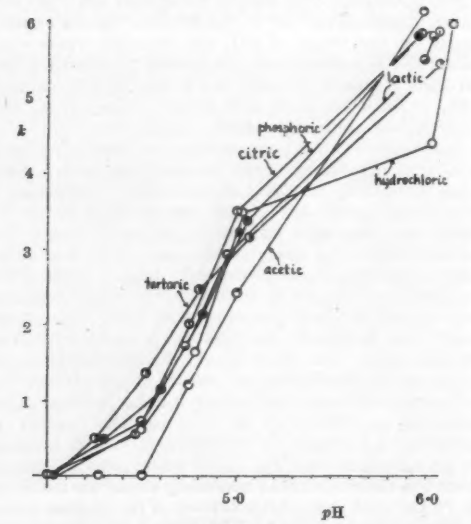

Fig. 1

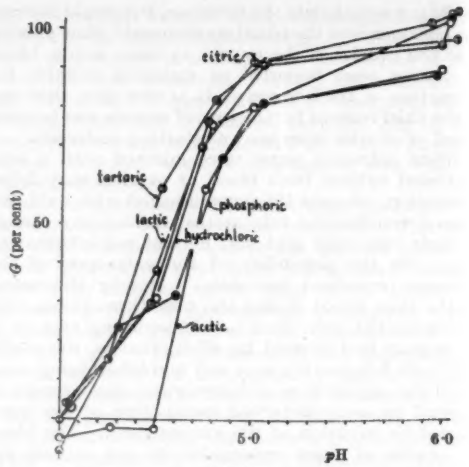

Fig. 2

It is interesting to note that, by changing the *p*H value, changes in k and G do not run parallel. Going downwards from *p*H 6, the extent of germination remains essentially unaltered down to about *p*H 5 and drops rather suddenly between *p*H 5 and 4. Germination velocity, on the other hand, suffers strong reduction by changing the *p*H from 6 to 5 and this reduction continues to *p*H 4.

A detailed account of this work has been submitted to *Acta Microbiologica Acad. Sci. Hung.*

K. Vas
G. Proszt

Institute for Research in Canning,
Meat Packing and Refrigeration,
II, Herman O.-ut 15,
Budapest.

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A Non-Extractive Method for the Quantitative Estimation of Chlorophyll in Algal Cultures

The standard method for the quantitative estimation of chlorophyll usually involves the extraction of this fat-soluble pigment in either ether, acetone, or alcohol. When quantities of chlorophyll are large, as is frequently found in culture experiments, large errors may result from incomplete extraction.

Goldberg *et al.*[1] introduced a cell-counting method, utilizing the millipore filter, which was rendered transparent by the addition of cedar oil. In the same manner a portion of algal culture may be concentrated on a millipore filter, quickly dried, cleared with cedar oil, and pressed between two cover glasses. The slide may then be examined in a spectrophotometer and the concentration of chlorophyll determined from the optical density of the principal absorption peak.

A measured portion of an algal culture is concentrated on a millipore-type '*AA*' filter (47 mm.

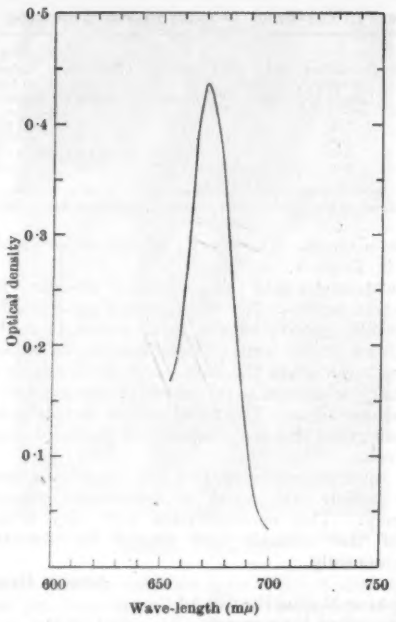

Fig. 1. Absorption of *Phaeodactylum* cells on a clear millipore filter, between wave-lengths 750 and 600 mμ

diameter). The filter is quickly dried at 85° C. for 10 min. Preliminary examination has shown that the short exposure to heat does not damage the pigment. The dried filter is placed on a No. 2 35 mm. × 50 mm. cover glass to which several drops of cedar oil are added. A second cover glass is placed on top, and the two glasses with the filter between are firmly pressed together. The residual filter is carefully cut away and the excess cedar oil is wiped from both glasses.

The 'wafered' filter is placed in one half of the standard Beckman *D.U.* 5·0-cm. cell carriage. A backing block of brass ensures the centring of the filter directly behind the opening in the cell carrier. Air is used as the blank standard. Monochrometer slit-widths range between 0·02 and 0·06 mm.

The spectrum of *Phaeodactylum* cells on a cleared millipore filter is shown in Fig. 1. The principal peak is at 670 mμ, which agrees with other workers' findings for chlorophyll absorption within the cell. Acetone, ether and alcohol solvents shift this peak to 655–665 mμ. Optical density readings at 670 mμ are the sum of absorption and scattering. The scattering, however, arises from particles much larger than the wave-lengths of light encountered; hence all visible wave-lengths in the red spectrum are scattered equally, not selectively, as is the case when the particle size approaches the dimensions of the wave-length. Therefore, scattering may be detected at 750 mμ where pigment absorption is negligible. Table 1 shows optical density measurements at 670 mμ and 750 mμ using air as one reference and the cleared filter as the other. About 50 c.c. of *Phaeodactylum* culture had been filtered. Using air as the reference, the optical density at 670 mμ is the sum of chlorophyll absorption and scattering resulting from the cedar oil complex and the cellular material on the filter. True chlorophyll absorption is the difference

Table 1. Comparison of Scattering Corrections

Wave-length (mμ)	Optical density (Ref.: air)	Optical density (Ref.: cleared filter)
670	0·120	0·069
750	0·064	0·013
Corrected O.D. 670	0·056	0·056

between optical density readings at 670 and 750 mμ. When a cleared filter is used as the reference, the optical density at 750 mμ is representative of particulate material on the filter. In the example shown in Table 1, about 80 per cent of the scattering resulted from the cedar oil filter complex, thus indicating that the refractive indices of cedar oil and cell material are about the same.

To calibrate this method, comparisons with acetone extracts were made. The methods for concentrating, extracting and determination have been outlined by Richards with Thompson[2] and Creitz and Richards[3]. Table 2 shows the ratios for seven species between the corrected optical density at 670 mμ and milligrams of chlorophyll *a* in the acetone extract. For most of the cultures listed only two determinations were made at different concentrations; however, *Dunaliella* and *Phaeodactylum* cultures were calibrated from six comparisons each, covering a wide range of concentrations. Chlorophyll in milligrams per litre of filtered culture may be calculated by using these ratios in the following formula:

$$\text{Chlorophyll } a \text{ (mgm./litre)} = \frac{(\text{O.D.})\,(K)}{\text{Volume filtered in litres}}$$

where O.D. $= D_{670} - D_{750}$. It should be noted that, in the calibration procedure, the optical density at 670 mμ has been compared directly with values obtained for chlorophyll *a*. Some interference by other chlorophylls can be expected at this wave-length; however, this probably does not exceed 5 per cent of chlorophyll *a*.

As only a small portion of the entire filter is examined in the spectrophotometer, large errors could result from the accumulation of cells in particular sections of the disk. By rotating the filter so that the light-path passes through three different areas, the maximum deviation recorded was 15 per cent.

The non-extractive method is much more sensitive than direct estimates of pigment from cell suspensions. It is comparable in sensitivity to optical density measurements on chlorophyll–acetone solutions using a 5·0-cm. light-path. The common use of the millipore filter makes the non-extractive

Table 2. Ratio (*K*) between Chlorophyll *a* (mgm.) in Acetone Extract (*A*) and the Corrected Optical Density Values at 670 mμ (*B*) for Equivalent Volumes of Filtered Cultures

		*A**	*B*	$K = \frac{A}{B}$
Skeletonema costatum	I	$4{\cdot}00 \times 10^{-2}$	0·039	0·102
	II	$7{\cdot}50 \times 10^{-2}$	0·071	0·105
Chaetoceras sp.	I	$1{\cdot}11 \times 10^{-2}$	0·022	0·131
	II	$2{\cdot}50 \times 10^{-2}$	0·049	0·130
Lauderia sp.	I	$1{\cdot}24 \times 10^{-2}$	0·030	0·105
	II	$2{\cdot}20 \times 10^{-2}$	0·052	0·104
Phaeodactylum tricornutum	I	$1{\cdot}44 \times 10^{-2}$	0·033	0·110
	II	$7{\cdot}00 \times 10^{-2}$	0·162	0·108
Dunaliella euchlora	I	$2{\cdot}02 \times 10^{-2}$	0·045	0·114
	II	$4{\cdot}05 \times 10^{-2}$	0·092	0·111
Nannochloris sp.	I	$1{\cdot}16 \times 10^{-2}$	0·026	0·103
	II	$3{\cdot}36 \times 10^{-2}$	0·081	0·104
Olisthodiscus sp.	I	$1{\cdot}66 \times 10^{-2}$	0·032	0·130
	II	$4{\cdot}00 \times 10^{-2}$	0·077	0·131

* 5 c.c. 90 per cent acetone extract

method highly desirable in studies involving carbon-14 uptake and chlorophyll analysis.

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Charles S. Yentsch

Woods Hole Oceanographic Institution,
Massachusetts.
March 26.

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Conversion of Phytoplankton to Zooplankton

One of the major problems in the efficient production of food by mass cultivation of unicellular algae is harvesting the crop. Centrifugation, the accepted method in the harvest of algal suspensions, is an expensive operation. Other procedures which have been used are gravitational settling of the heavy cells[1] and flocculation by addition of special agents[2].

The conversion of phytoplankton to zooplankton by feeding algae to appropriate animals, and harvesting these animals, is another possibility. The feasibility of this procedure will depend on the efficiency of the conversion. Estimates based on the rate of growth and respiration of some zooplankton organisms indicated high efficiency for this conversion; up to 70 per cent of the metabolized plant material was converted to animal matter[3].

Conversion efficiency so estimated refers to the percentage of the plant material which was ingested, digested, absorbed and metabolized, and does not indicate the efficiency in terms of total plant material used by the animal per weight of animal produced.

A preliminary experiment was performed to establish the approximate value of this more practical conversion efficiency. The green unicellular alga *Dunaliella viridis* was fed to the brine shrimp *Artemia*. The alga was cultivated in sea water enriched with 1 gm. potassium nitrate, 200 mgm. dipotassium hydrogen phosphate per litre under continuous illumination. A varying number of newly hatched *Artemia* nauplii were counted into several glass vessels containing 200 ml. of sea water. The vessels were kept in the dark, and equal quantities of algal suspensions were added daily. The packed volume of the algae in the added suspensions was determined at the same time. After nine days the animals were harvested, blotted and weighed. Dry weight was determined after drying overnight at 105° C. The total packed volume of algae fed during the experiment was 0·290 ml. per vessel. The wet and dry weights of 1,000 hatched *Artemia* nauplii before feeding were 14 and 2 mgm. respectively. The packed volume of the solids left in the water, including fæcal pellets and uneaten algae, was also determined. The results of this experiment are given in Table 1.

Table 1. Conversion of Plant to Animal Material

No. of animals	Initial wet weight (mgm.)	Final wet weight (mgm.)	Initial dry weight (mgm.)	Final dry weight (mgm.)	Packed volume of fæcal pellets (ml.)
100	1·4	34	0·2	4·8	0·250
198	2·8	60	0·4	8·4	0·200
382	5·5	129	0·75	15·8	0·170
750	9·8	164	1·5	18·0	0·130

In each series the total packed volume of algae fed was 0·290 ml.

It is apparent that the conversion efficiency based on the wet weights of the animals and algae (assuming the specific gravity of the algae to be 1) could be as high as 53 per cent. The efficiency, as expected, is much lower when the amount of the available algal material per animal is in excess of the amount it is able to assimilate. The fæcal pellets in this instance are dark green and are composed of partially digested algal cells.

An optimal concentration of algae per animal exists which will yield a maximum conversion efficiency. This concentration will vary with the age of the animals and should be determined experimentally.

Ahron Gibor

Hopkins Marine Station of
Stanford University,
Pacific Grove, California.

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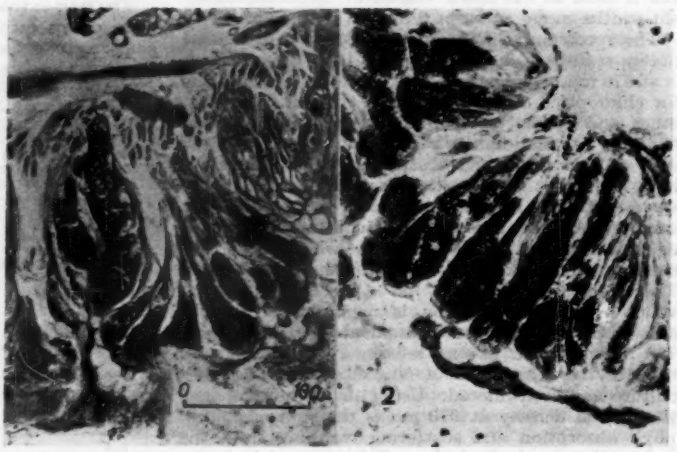
A Cytoplasmic Polyhedral Disease of the Gypsy Moth (*Lymantria dispar* L.)

During 1954 and 1955 we investigated an outbreak of the gypsy moth in middle Slovakia and collected material from infested oak forests. In some of the caterpillars reared from these samples the fæces were abnormally white. Examination of these under the optical microscope revealed the presence of great quantities of polyhedra-like bodies. This was



Figs. 1 and 2. Longitudinal sections of the gut epithelium of the larva of the gypsy moth, *Lymantria dispar*, infected with a cytoplasmic polyhedrosis

Fig. 3. A gut cell filled with polyhedra; note that the nucleus contains no polyhedra

unexpected, since only one type of polyhedral disease has so far been described from the gypsy moth, a nuclear polyhedrosis affecting many organs of the caterpillar but not the gut. Infected larvæ progressively lost their appetite and finally died, revealing in dissected specimens a milky white gut.

Although Xeros[1] and Smith and Xeros[2] have recorded successful infection of gypsy moth larvæ with a cytoplasmic virus from the gut of *Arctia villica*, this is the first recorded occurrence of a natural infection in this species with a cytoplasmic virus.

For a histological study of the disease, larvæ were fixed in Bouin–Dubosque–Brazil fluid and sections 5μ thick were cut and stained with Ehrlich's and Heidenhain's hæmatoxylin. The polyhedra were found only in the cells of the gut and in no other organs of the infected larvæ; they occurred in the cytoplasm and not in the nuclei. No cases of double infection with both cytoplasmic and nuclear polyhedroses were observed.

After artificial infection in the laboratory, larvæ of the fifth instar died in about two weeks, infectivity being nearly 100 per cent.

There seems little doubt that the natural means of spread of the virus is by way of contaminated food. Whether there are other methods of infection, either natural or artificial, is a matter for further investigation.

In cross-inoculation studies it has been established that the polyhedra are infectious and cause similar diseases in other lepidopterous larvæ such as those of the silkworm (*Bombyx mori*) and the brown-tail moth (*Euproctis chrysorrhoea*).

In most cases the polyhedra are hexagonal in shape and range in size from 0·5 to 4μ in diameter with an average of 1–2μ. They are dissolved by *N*/20 sodium hydroxide but not by *N* hydrochloric acid. After previous treatment with the latter, dry smears of polyhedra stain well with Giemsa's solution. There is no uniformity in the production of polyhedra in the different cells of the gut, and while there is great variation in the size of the polyhedra in different cells, they are usually of the same size in individual cells. This is probably governed by the number of polyhedra in each cell. A more detailed study of this new disease is in course of preparation.

J. Veber

Institute of Biology,
Czechoslovak Academy of Sciences,
Prague 6, Na cvičišti 2,
Czechoslovakia.

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Spatial Facilitation in the 'Direct' Inhibitory Pathway

Of the various inhibitory actions converging on to spinal motoneurones the 'direct' inhibition is the one that has been the most extensively investigated[1–6]. It is provoked by impulses in large muscle afferents from annulo-spinal endings (I*a* fibres)[7–9]. Monosynaptic excitatory action to motoneurones is also supplied by I*a* fibres, and, with any particular group of motoneurones, the inhibitory action is caused by I*a* fibres originating from the muscles antagonistic to those supplying excitatory action. The 'direct' inhibitory action is caused by a brief hyperpolarization of the motoneuronal membrane, the inhibitory post-synaptic potential[10]. The inhibitory post-synaptic potentials have a minimal latency of about 1·2–1·4 msec. relative to the time when the I*a* volley reaches the spinal cord or approximately 0·8 msec. longer than for the monosynaptic excitatory post-synaptic potential. It has been postulated that this longer latency is due to the existence of an inter-

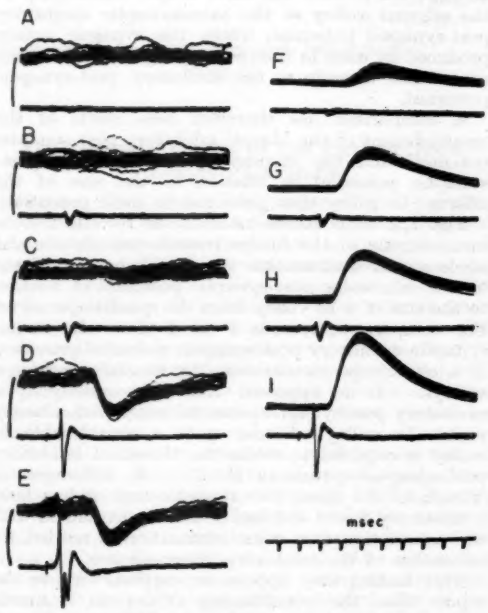

Fig. 1. Intracellular recording from a posterior biceps-semitendinosus motoneurone (*A–E*) and from a quadriceps motoneurone (*F–I*). The two sets of records show the establishment of 'direct' inhibitory post-synaptic potential and the monosynaptic excitatory post-synaptic potential relative to the size of I*a* quadriceps volleys. Record *E* shows that the quadriceps volley with respect to conduction velocity displayed the separation into I*a* and I*b* components. Records *D* and *I* were obtained with maximal I*a* volley with inclusion of only a small fraction of the I*b* component

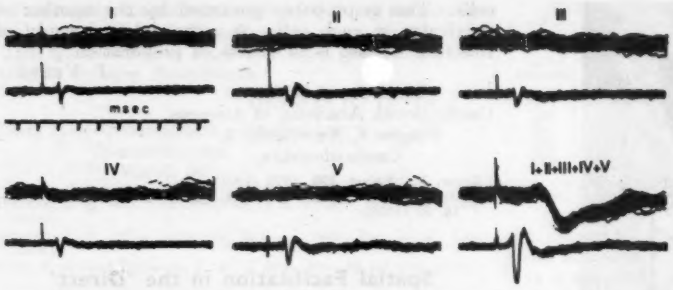

Fig. 2. Intracellular recording from a posterior biceps-semitendinosus motoneurone. The quadriceps nerve was divided into five branches. Records I–V show that maximal group I volleys in either of these branches failed to evoke any 'direct' inhibitory post-synaptic potential, whereas synchronous volleys in all five branches (I + II + III + IV + V) evoked a large inhibitory post-synaptic potential

neurone in the 'direct' inhibitory pathway, and experimental evidence has been presented suggesting that these interneurones are located in the intermediate nucleus[11].

According to this hypothesis, the establishment of the inhibitory post-synaptic potential depends on synaptic excitation of the inhibitory interneurones by the primary afferent volley. Generally, synaptic excitation of cells in the central nervous system is known to require spatial summation, that is, activity in several presynaptic fibres. The question may therefore be raised if some summation would not be needed for excitation of the inhibitory interneurones by the I*a* impulses. If so, the direct inhibitory post-synaptic potential in the motoneurones would not be expected to have the same simple relationship to the afferent volley as the monosynaptic excitatory post-synaptic potential, where the synaptic action produced by each I*a* fibre converging on to a neurone contributes directly to the excitatory post-synaptic potential.

A comparison has therefore been made of the establishment of the 'direct' inhibitory post-synaptic potential and the monosynaptic excitatory post-synaptic potential in relation to the size of the afferent I*a* volley that gives rise to these potentials.

Fig. 1, *A* to *E* shows intracellular records from a motoneurone of the biceps posterior-semitendinosus nucleus and demonstrate the establishment of the 'direct' inhibitory post-synaptic potential in relation to the size of a I*a* volley from the quadriceps nerve. For comparison, records *F* to *I* show the monosynaptic excitatory post-synaptic potential provoked in a quadriceps motoneurone by similar quadriceps volleys. It is apparent that the monosynaptic excitatory post-synaptic potential arises with a barely visible I*a* volley whereas quite a considerable I*a* volley is required to evoke the threshold inhibitory post-synaptic potential in *C*. A difference in 'threshold' for these two synaptic actions has been consistently found and can be readily explained with the assumption that some summation is needed for excitation of the inhibitory interneurones.

This finding may appear as contradictory to the report that the conditioning effects on a monosynaptic test reflex by a 'direct' inhibitory volley as well as by a volley giving monosynaptic facilitation are provoked by the lowest threshold group I fibres[9]. However, this observation was made on unanæsthetized spinal cats, whereas the present experiments were carried out on cats under nembutal anæsthesia. It is possible that little summation would be needed for excitation of inhibitory interneurones in a state of high excitability and that the depressed excitability caused by the anæsthetic is favourable for the demonstration of this phenomenon.

It is possible to prove that I*a* fibres activated by a stimulus subthreshold for evoking this 'direct' inhibitory post-synaptic potential are a link in the inhibitory pathway to the neurone from which recording is made. Fig. 2 illustrates an experiment with intracellular recording from a biceps posterior-semitendinosus motoneurone. The quadriceps nerve was subdivided into five branches, and a supramaximal group I volley in any particular branch (I, II, III, IV or V) failed to evoke a 'direct' inhibitory post-synaptic potential, whereas synchronous volleys in all of them (I, II, III, IV, V) provoked the usual large inhibitory post-synaptic potential. This finding would be extremely difficult to explain, unless it be assumed that there is an interneurone in the inhibitory pathway. Presumably each of the quadriceps branches failed to have any discharge zone of inhibitory interneurones, but supplied subliminal excitation as evidenced by the spatial facilitation.

The general importance of this finding should be seen in relation to the hypothesis that synaptic actions are exerted by liberation of chemical transmitters and that the primary afferent neurone manufacturing an excitatory transmitter substance is followed by a neurone specialized to produce the inhibitory transmitter[11].

R. M. Eccles
A. Lundberg

Department of Physiology,
The Australian National University,
Canberra, Australia.

March 4.

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Effect of Actinomycin *M* upon Mitosis

Actinomycin *M* is an antibiotic produced by a species of *Streptomyces* resembling, but not identical with, *S. antibioticus*. This organism and the physical, chemical and biological characters of the antibiotic have already been described[1]. We now wish to record its effects upon mitosis of different types of cell.

The following tissues were examined: (*a*) chick embryo basophilic erythroblasts, *in vivo*; (*b*) *Allium cepa* root meristem; (*c*) chick embryo fibroblasts in tissue culture; (*d*) lymph glands, testes, tonsils, spleen and intestinal glands of rabbits.

The methods employed for *a*, *b* and *c* have been described[2,3]. In the case of *d*, three groups each of six animals were taken; two received 100 and 400 mmgm./kgm., respectively, by intraperitoneal injection; the third group was the control. The animals were killed at intervals for examination.

The main results may be summarized as follows.

(1) Progressive fall in mitotic index. This was observed even with very low concentrations (5 mmgm./kgm.) in the chick embryo tissues, but the onion root was less sensitive. In the rabbits, the effect was most marked in the lymph glands and spleen.

(2) Retardation of the initial phases of mitosis, as indicated by a progressive increase in the relative proportions of prophases compared with anaphases and telophases. This occurred in all types of cell with relatively high dosages.

(3) Cytoplasmic and nuclear vacuolation, nuclear hypertrophy, pycnosis, caryorexis and caryolysis in actively proliferating cells, but little effect in non-proliferating cells. The germinative tissue of the rabbit testis was exceptional in that it was also unaffected.

(4) Chromosome lesions, adhesions, breakages and bridges with eccentric fragments.

(5) Absence of effects upon the spindle, in contradistinction[4] to actinomycin *C*.

These effects suggest that actinomycin *M* is a mitotic poison acting mainly on the chromosomes in preprophase. It may be classified as 'radiomimetic' since it simulates the action of X-rays.

R. Craveri
Montecatini Antibiotic Research Laboratory.
U. Veronesi
National Cancer Institute,
Milan.

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An Antibiotic with Fungicidal and Insecticidal Activity produced by *Streptomyces*

In the course of our investigations of antibiotic-producing *Streptomyces* a substance was isolated, from a strain of the *S. tanaschiensis* type, that could not be identified with any previously recorded antibiotic, and which was active against fungi and also against insects. We have named it 'flavensomycin'.

The organism was cultured in a medium of 2 per cent maltose, 0·5 per cent peptone and 0·25 per cent corn steep liquor in tap water at laboratory temperature, in a shaking device. Maximum production was achieved in about five days. The medium was extracted with benzene and dried *in vacuo* until precipitation occurred; the crude precipitate was washed in petroleum ether and extracted in acetone, the insoluble portion being discarded. Addition of petroleum ether (4 : 1) gave an amorphous orange-yellow precipitate, the crude flavensomycin.

Further purification was carried out in an alumina column. The antibiotic was first applied in the form of a solution in benzene, the column washed thoroughly with benzene followed by ethyl acetate and finally by a mixture of ethyl acetate and ethanol. These solvents removed coloured, inactive fractions. The pure antibiotic was eluted with methanol, and recovered by concentration *in vacuo* at laboratory temperature.

Purified flavensomycin consists of pale yellow, odourless tabular crystals, with melting point 152° ± 2° C., soluble in water, lower alcohols and acetates, benzene, pyridine, acetone, dioxane and propylene glycol; insoluble in ether, petroleum ether, hexane, carbon tetrachloride and carbon disulphide. It contains nitrogen but no sulphur or halogens, and gives some reactions associated with carbohydrate but not with protein components. Ehrlich's reaction is positive. The ultra-violet absorption spectrum (20 mmgm./ml. in methanol) has one maximum at 251 mμ, the infra-red has a series of maxima from 3 to 13μ.

Flavensomycin is stable is the dry form and in solution in organic solvents. Aqueous solutions keep best below 18° C., at *p*H 6–7·5.

The lethal dosage in the mouse is 1 mgm./kgm. intraperitoneally, 2 mgm./kgm. subcutaneously and 25 mgm./kgm. orally.

Dilutions in the region of 0·05 mmgm./ml. are active against *Saccharomyces* among the yeasts and *Penicillium* among the filamentous fungi; and higher concentrations (5–50 mmgm./ml.) against a wider range. Bacteria are resistant to concentrations less than 100 mmgm./ml.

Flavensomycin is also active against insects, including *Musca domestica* and *Locusta migratoria*. Using the standard screening techniques, on the former, it has an activity ten times greater than DDT.

R. Craveri
G. Gioliti
Montecatini Antibiotic Research Laboratories,
Milan.

The Generic Name of the Extinct New Zealand Gallinule

During the course of the preparation of a review of the extinct birds of New Zealand and the Chatham Islands, it was discovered that a discrepancy of spelling occurred in the generic name assigned to the extinct New Zealand gallinule found in Pleistocene to Recent sites in New Zealand. Since reference has already been made by me in papers now in the press to this bird from deposits previously described[1–3], I now consider myself the "*First Subsequent User*" of the name, and it seems desirable that the situation regarding the proper use of this name should be made clear.

In 1955 Scarlett[4] described, without figures or comparative measurements, a small rail from Quaternary deposits in the Pyramid Valley swamp, North Canterbury, New Zealand, under the name of *Rallus hodgeni*. Oliver[5], in the revised edition of his book on New Zealand birds, living and extinct, has compared the type pelvis with *Gallinula*, *Tribonyx*, *Porphyrio* and *Notornis*, and concluded that it belonged to a gallinule "closely allied to *Tribonyx*". On p. 595 of his book, he listed this extinct bird as belonging to a new genus, "*Pyramida* N.Gen." (Family Gallinulidae), while further on (p. 596) he gave the type species as "*Pyramidia hodgeni*" from the Pyramid Valley swamp founded on the type pelvis described by Scarlett earlier in the year.

This situation, arising where a name is published with more than one spelling, was dealt with by the Fourteenth International Congress of Zoology in Copenhagen, 1953, which decided, as later published in Decision 71 (1) (*a*) (ii), that "Where there was more than one Original Spelling and in the case of none of these spellings was there clear evidence that it was the result of an inadvertent error, the *Valid Original Spelling* is that one of the Original Spellings used by the *First Subsequent User* of the name"[6].

Although on p. 596 of his book Oliver again used the spelling "*Pyramida*" when he stated: "Apparently *Pyramida* is closely related to *Tribonyx*", and although in the index on p. 657 is listed the entry "*Pyramida*, 595", there is little "clear evidence" as to whether he intended to use the spelling "*Pyramida*" or "*Pyramidia*". The first mention of this bird in the book is in the preface on p. 16 where it is listed as "*Pyramida hodgeri*" [*sic*]. This is only one of the numerous errors, typographical or otherwise, which occur in this book. However, it does seem likely that "*Pyramida*" was intended, and, although I have searched the relevant literature, including reviews and abstracts, I can find no other user of this name since 1955 apart from my own reference in the press as "*First Subsequent User*". I feel, in view of the confusion that would otherwise inevitably result, that it is advisable to place on record the reason why "*Pyramida*" must be used as the correct spelling for the generic name of the extinct New Zealand gallinule.

I am indebted to Mr. Francis Hemming for his encouragement and advice on this (private communication) and other points in connexion with names of the extinct birds of New Zealand, and I must also thank Dr. C. F. A. Pantin for his interest. I should also like to pay tribute to the late Dr. W. R. B. Oliver, to whom I am indebted for my initial interest in this field.

E. W. Dawson

Trinity College,
Cambridge.
March 11.

[1] Dawson, E. W., *N.Z. Bird Notes*, **3**, 132 (1949).
[2] Dawson, E. W., *Emu*, **52**, 259 (1952).
[3] Yaldwyn, J. C., *Rec. Dom. Mus., Wellington*, **3**, 1 (1956).
[4] Scarlett, R. J., *Rec. Canterbury [N.Z.] Mus.*, **6**, 262 (1955).
[5] Oliver, W. R. B., "New Zealand Birds" (Reeds, Wellington, 1955).
[6] Hemming, F., "Copenhagen Decisions", 43 (London, 1953).

Use of the Electronic Flash to record the Activity of Small Animals

During field-observations of mosquitoes (*Aedes caspius* Pall.) in Abu Ghraib, Iraq, it was found that the insects were not disturbed when being photographed by means of an electronic flash; in this they resemble birds, small mammals and diurnal insects. The firing of ordinary flash bulbs will always cause resting mosquitoes to fly away; and swarming males will disperse for a period of several minutes after a flash-bulb exposure. The firing of an electronic flash, even from as close as 30 cm., did not appear in any way to disturb resting or feeding mosquitoes, and not the slightest change in pitch of male swarms was discernible when they were photographed by the same device. It is not known if the insects react differently to the two light sources because of differences in the duration of light, or whether the disturbance produced by the ordinary flash bulb results from the considerable emission of radiant heat. But whatever the reason, it seemed that this indifference to the electronic flash could be used for recording photographically the activity of small and light insects.

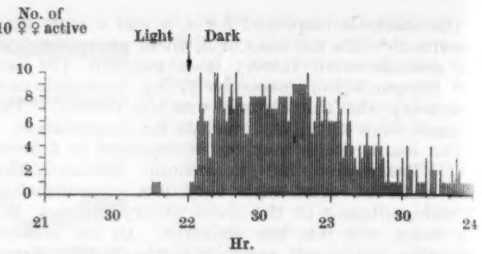

Fig. 1. Activity of ten female *Aedes taeniorhynchus* caused by the change from light to darkness

It is well known that the activity of many animals, especially nocturnal ones, shows a periodicity directly or indirectly dependent on the daily variation in light between day and night, and many methods of recording the activity of animals have been described. Most of these operate on the principle that displacement of the weight of the animal causes a mechanical displacement which is in some way recorded[1]. This method, however, is not easy to use with animals weighing only a few milligrams. It would be much more convenient to take pictures of the animals at suitable intervals; but this has so far met with the difficulty of getting pictures during the dark periods. If the animals do not react to the electronic flash as light, however, it should be possible to record photographically the activity by means of a synchronized electronic flash independently of the changing illumination used to produce the activity periods. This has been found to be possible.

The animals (mosquitoes) are enclosed in a chamber 45 mm. × 35 mm. and 15 mm. deep. The front wall is a glass plate through which the animals are exposed to light simulating day and night periods, and through which they are photographed every minute by means of a recording camera. The camera is synchronized with the electronic flash, which illuminates the animal chamber from behind through two plates of opal glass, one of which is the back wall of the chamber. A detailed description of the apparatus will be published later.

By using the displacement of one individual between two successive pictures as a unit of activity, it is possible to get a detailed quantitative expression for activity. It is possible also to record the movement of several individuals simultaneously under identical conditions. The possibility of seeing what the animals actually are doing, thus facilitating the analysis of special types of behaviour, is perhaps the greatest value of the method.

That at least some insects are indifferent to the electronic flash has certainly facilitated the study of activity; it may be useful also in other areas of study.

Erik Tetens Nielsen

Entomological Research Center,
Florida State Board of Health,
Vero Beach, Florida.
Feb. 22.

[1] Hemmingsen, Axel M., and Krarup, Niels B., *Biol. Medd. Kgl. Danske Vid. Selsk.*, **13**, 7 (1937). Park, Orlando, *Ecology*, **16**, 152 (1935). Szymanski, J. M., *Pflügers Arch.*, **158**, 343 (1914).

A Species of the Genus *Venturia*, the Ascigerous Stage of *Fusicladium carpophilum* (Thum.) Oudem

In 1877, under the name *Cladosporium carpophilum* Thüm., the type-specimen of the species *Fusicladium carpophilum* (Thüm.) Oudem. was described on peach fruits, grown in Austria. Since that time, the species has been recorded from most parts of the world on apricots, plums and almonds, as well as peaches.

Although 'freckle', the disease caused by *F. carpophilum*, is of world-wide distribution and of considerable economic importance, the perfect stage in the life-history of the pathogen has until recently remained obscure.

At the close of winter, August 1955, fallen leaves were collected from a 'freckle'-infected apricot orchard at Inverleigh, Victoria, where foliage symptoms had been observed the previous season[1]. A number of bicellular, 'olive buff'[2] spores were ejected from these leaves and collected on microscope slides according to the method described by Leroy Childs[3]. The germination of these spores on potato-dextrose agar gave rise to an olivaceous mycelium bearing conidia of the *Fusicladium* type. The pathogenicity of these fungal cultures was afterwards proved when, in October 1955, branches of healthy apricot trees growing in a 'freckle'-free area at Burnley, Victoria, were atomized with a water suspension of *Fusicladium* conidia. Typical 'freckle' lesions developed on the fruits five weeks after inoculation; leaf symptoms appeared later, and were not observed until eight weeks after inoculation.

Concurrently with this cultural investigation, a histological examination of the overwintered apricot leaves revealed spherical to sub-spherical perithecia immersed in the leaf-tissue, each perithecium opening by means of a well-defined ostiole, on to either upper or lower surface of the leaf. The perithecia, which measured from 60 to 160μ in diameter, may be described as generally glabrous, with bristles present only occasionally. Each perithecium contained 8-spored, saccate-cylindrical asci, measuring 48–56μ in length × 5–6μ in width. The 'olive-buff' ascospores measured 12–16μ in length × 3–5μ in width, each spore being divided by a median septum into two cells of equal length. Usually, the cell directed towards the apex of the ascus was conspicuously broader than the lower one, being sometimes almost spherical and quite distinct from the tapering lower cell of the ascospore.

On the basis of these observations the 'apricot freckle' fungus is identified as a species of the genus *Venturia*.

A close affinity might be expected with the species recorded on overwintering, 'scab'-infected cherry leaves which was named *V. cerasi* by Aderhold[4]. However, *V. cerasi*, as described by Aderhold, differs from the apricot fungus now described in that the upper cell of the ascospore is characteristically pointed and longer than the lower cell.

Furthermore, Bensaude and Keitt[5] demonstrated that the cherry scab fungus differed from the *Cladosporium* pathogens of other stone fruits first in cultural characters and secondly in pathogenicity, which was found to be specific to the cherry.

The validity of these distinctive features is being investigated and a detailed account of this study, including the specific identification of the apricot fungus, will be published at a later date.

Eileen E. Fisher

Biology Branch,
Victorian Department of Agriculture,
Melbourne,
Australia.
March 1.

[1] Fisher, E. E., and Jenkins, P. T., *J. Dept. Agric. Vic.*, **52**, 265 (1954).
[2] Ridgway, R., "Color Standards and Color Nomenclature" (Washington, D.C., 1912).
[3] Childs, Leroy, Oregon Agric. Exp. Sta. Bull. 143 (1917).
[4] Aderhold, R., *Landw. Jahr.*, **29**, 541 (1900).
[5] Bensaude, M., and Keitt, G. W., *Phytopath.*, **18**, 313 (1928).

Preparation of Large Histological Sections of Mummified Tissues

I have described elsewhere a method for the preparation of satisfactory histological sections of Egyptian mummy tissues and outlined some of the results obtained by current staining methods[1]. This method was designed for small portions of tissue only and comprised a double-embedding method by hand transference after rehydration of the desiccated tissues. By adapting this technique to the automatic processing method of Russell[2], it has now proved possible to prepare large blocks of mummy tissue for the microtome, using a 'Histokinette-Histokine'. The material is processed in perforated metal cassettes of the requisite size (supplied by Hendrey's, Ltd.). The process employed utilizes a 5-day cycle, and the quality of block produced is such that sections are readily obtained, without subsequent softening, on a standard Cambridge rocking microtome.

The method is particularly useful in the preparation of large sections of bone after decalcification by

Fig. 1. Section of cervical vertebra of male Egyptian mummy. Heidenhain's iron haematoxylin. × 1½

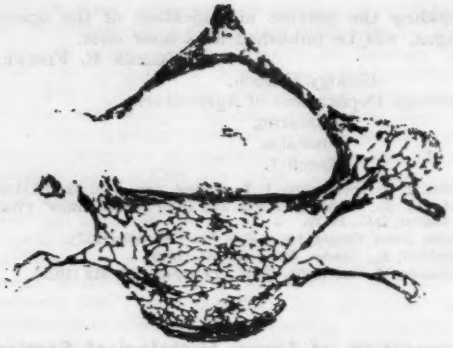

Fig. 2. Section of external ear and of mastoid portion of temporal bone of same mummy. Heidenhain's iron hæmatoxylin. × 1½

the ion-exchange method using 'Zeo-Karb 225/*M*' (Light and Co., Colnbrook). Satisfactory sections have also been obtained after decalcification with De Castro's fluid. In this way sections have been made of the larger tarsal bones, for example, calcaneus and talus, of entire cervical vertebræ (Fig. 1), of the mandible with teeth *in situ* and of the temporal bone (Fig. 2). The quality of section produced depends, of course, on the state of preservation of the bone in question. Some indication of this may be obtained by preliminary radiography of the material.

It may also be used for the sectioning of large portions of soft tissues and has given excellent sections of the entire external ear, the orbital contents[2] and of the vascular bundles of the lower limb. The staining methods which may with profit be employed and the results to be anticipated are discussed in my previous paper[3].

The method should be of value in investigating osseous lesions in Egyptian or other mummies and indeed in any desiccated human skeletal material, especially if associated with skilled radiography. It should also be the method of choice for general palæo-histological work.

A. T. Sandison

Department of Pathology of the
University and Western Infirmary,
Glasgow.
March 6.

[1] Sandison, A. T., *Stain Tech.*, **30**, 277 (1955).
[2] Russell, N. L., *J. Med. Lab. Tech.*, **13**, 484 (1956).
[3] Sandison, A. T., *Med. Hist.* (in the press).

Shape Discrimination in the Octopus

In a recent communication[1], P. C. Dodwell raises some doubts about the adequacy of a theory of visual shape discrimination in octopus which I outlined in *Nature*[2]. Dodwell makes four points: (1) He thinks it would be difficult to devise an analysing mechanism which would analyse relative differences in rates of firing at different points over a row of neurons: such a mechanism is necessary on my theory to explain the discrimination of certain figures (for example, a square and a circle). (2) He maintains that the theory fails to account for discrimination of shape irrespective of the locus of excitation on the retina. (3) He writes: "the reason for postulating the array of cells [in the optic lobes] becomes obscure, because . . . the analyser . . . should enable it to deal directly with information from the retina". (4) He maintains that a theory of shape discrimination which he is putting forward overcomes the difficulties inherent in my own theory by transforming a spatial pattern into a temporal pattern.

Since Dodwell's points involve some misunderstanding of my own position, I would like to reply briefly to these points seriatim.

(1) (*a*) It is known that the nervous system can respond to differences in rates of firing over a row of cells. In discriminating a bright light to the left of a dim light from a dim light to the left of a bright light, the nervous system is performing just that analysis. (*b*) The analysing mechanism that must be postulated on my theory to account for discrimination between squares and circles is more complex than that which operates to analyse the difference between a vertical and a horizontal rectangle: it is precisely this difference in complexity which explains why the former pair of figures are found to be more difficult for an octopus to discriminate than the latter pair. (*c*) It is not difficult to design plausible neural analysing mechanisms which will classify separately the outputs given on my theory by squares from those given by circles. For example, a nervous mechanism which analyses changes in the rate of firing at points along a row of cells excited can readily be envisaged, and the difference between the outputs from such figures can be specified in these terms. What is difficult to decide (on the present evidence) is which of the many different possible analysing mechanisms that might be incorporated is the one actually operating.

(2) A mechanism responding to changes in the rate of firing would go some way towards accounting for generalization both to figures projected on different parts of the retina and to figures of different sizes. There is no reason, however, why, on my own theory, temporal coding should not be introduced at this stage. Although temporal coding has often been suggested by psychologists as a way of mediating generalization to figures projected on different parts of the retina, it seems to lack plausibility on neurophysiological grounds and for this reason I would prefer to avoid it.

(3) I do not "postulate" an array of cells in the optic lobes of octopus on to which the retina is projected: they are there. There are many functions such a projection might have—for example, to ensure that only one shape is analysed at a time.

(4) Dodwell's claim to have devised a theory of shape recognition which overcomes the difficulties in my own cannot be evaluated until he publishes his theory. My theory does not attempt to be a completely comprehensive explanation of shape recognition: it is intended primarily to explain my own experimental results. The detailed specification of further analysing mechanisms must wait until the theory has been thoroughly tested at its present stage of development, and until further evidence accumulates which makes it possible to choose between all the theoretically possible further analysing mechanisms.

N. S. Sutherland

Institute of Experimental Psychology,
University of Oxford.

[1] Dodwell, P. C., *Nature*, **179**, 1088 (1957).
[2] Sutherland, N. S., *Nature*, **179**, 11 (1957).

FORTHCOMING EVENTS

Wednesday, June 26

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. Shirley: "The Carboniferous Limestone of the Monyash-Wirksworth Area, Derbyshire"; Dr. C. S. Exley: "Magmatic Differentiation and Alteration in the St. Austell Granite".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. W. R. Smithies: "New Developments in the Freeze Drying of Meat".

BRITISH PSYCHOLOGICAL SOCIETY, MEDICAL SECTION (at the Medical Society of London, 11 Chandos Street, Cavendish Square, London, W.1), at 8.30 p.m.—Dr. Edward Glover: "Future of Dynamic Psychology".

Thursday, June 27

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 9.30 a.m.—Conference on "Capital for Scientific Development: the Problems of its Supply for Industry".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

HEAD (with an honours degree, and preferably with industrial research and teaching experience) OF THE CHEMISTRY DEPARTMENT—The Registrar, The Technical College, Sunderland, Co. Durham (June 29).

SENIOR LECTURER (with some knowledge of experimental aerodynamics) IN THEORETICAL AERODYNAMICS—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks (June 30).

LECTURER (graduate in metallurgy or chemistry, with special qualifications in the theory of extraction metallurgy) IN METALLURGY—The Registrar, The University, Manchester 13 (July 1).

LECTURER IN BIOCHEMISTRY IN THE RHEUMATISM RESEARCH CENTRE—The Registrar, The University, Manchester (July 1).

ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8 (July 5).

ASSISTANT LECTURER IN PHYSICAL CHEMISTRY—Prof. R. M. Barrer, F.R.S., Imperial College, London, S.W.7 (July 5).

LECTURER IN PSYCHOLOGY—The Secretary, The University, Aberdeen (July 5).

DEMONSTRATOR or ASSISTANT LECTURER (with a good honours degree in physiology, biochemistry or chemistry with subsidiary physiology) IN CHEMICAL PHYSIOLOGY—The Registrar, The University, Manchester 13 (July 6).

LECTURERS (2) IN THE DEPARTMENT OF PHYSICS; a LECTURER IN THE DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING; an ASSISTANT (ORGANIC or INORGANIC) IN THE DEPARTMENT OF CHEMISTRY; and an ASSISTANT IN THE DEPARTMENT OF MATHEMATICS, Queen's College, Dundee—Joint Clerk to the University Court, The University, St. Andrews (July 6).

ASSISTANT (with a degree in horticulture or botany or equivalent experience) IN THE POMOLOGY SECTION, for work on plant anatomy and field experiments—The Secretary, East Malling Research Station, near Maidstone, Kent (July 8).

LECTURER IN SOIL SCIENCE in the Department of Geography—The Secretary, Durham Colleges in the University of Durham, 38 North Bailey, Durham (July 10).

LECTURER IN ORGANIC CHEMISTRY; and a LECTURER IN INORGANIC CHEMISTRY—The Secretary, The University, Aberdeen (July 11).

LECTURER or ASSISTANT IN PSYCHOLOGY—The Secretary of University Court, The University, Glasgow (July 12).

UNIVERSITY LECTURER IN THE PHILOSOPHY OF SCIENCE—Mr. J. D. Irwin, The Old Schools, The University, Cambridge (July 13).

ASSISTANT LECTURER (man or woman) IN ZOOLOGY—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey (July 15).

LABORATORY TECHNICIAN IN THE DEPARTMENT OF ANATOMY, Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 15).

PLANT BREEDER (with a good honours degree in botany or related subject and preferably postgraduate training in genetics), to study the utilization of hybrid vigour and general genetics of the tomato; and a PLANT PHYSIOLOGIST (with a good honours degree and postgraduate training in physiology or biochemistry) to study tree fruits—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford (July 17).

RESEARCH FELLOW (with an honours degree in chemistry, physics, or agricultural chemistry and experience in work in soils) IN SOIL SCIENCE at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 18).

CHAIR OF GEOGRAPHY in the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 19).

CHAIR OF EDUCATION in the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, July 20).

RESEARCH DEMONSTRATOR IN ZOOLOGY—The Registrar, The University, Reading (July 20).

SENIOR DEMONSTRATOR IN ORGANIC CHEMISTRY—The Registrar, University of Melbourne, Carlton, N.3, Victoria, Australia (July 20).

SENIOR LECTURER or LECTURER IN AGRICULTURAL CHEMISTRY; and a LECTURER IN ANIMAL HUSBANDRY at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 20).

NUCLEAR SCIENTIST or ENGINEER with the Australian Atomic Energy Commission for economic and technical studies of nuclear power developments in Australia—Australian Atomic Energy Commission Liaison Officer, Australia House, Strand, London, W.C.2 (Australia, July 22).

LECTURER IN BOTANY at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

SENIOR LECTURER or LECTURER IN PHYSIOLOGY in the Faculty of Rural Science—The Acting Registrar, University of New England, Armidale, N.S.W., Australia (July 31).

CHAIR OF ORGANIC CHEMISTRY—The Secretary, The Queen's University, Belfast (August 1).

ASSISTANT EXPERIMENTAL OFFICERS (with H.S.C. (Science) or equivalent qualification), to work on general health physics problems, including radiation monitoring on reactors, design of radioactive buildings from the radiation safety aspect, and the evaluation of new techniques for the estimation of radioactive materials for a site monitoring programme—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 1510/34.

ASSISTANT PROFESSOR IN ELECTRICAL ENGINEERING—The University of New Brunswick, Fredericton, N.B., Canada.

GEORGE MARTIN LEES RESEARCH FELLOW (with the degree of Ph.D. or other postgraduate research experience) IN SEDIMENTOLOGY—The Registrar (Room 9 O.B.B.), The University, Reading.

HEAD (with high academic qualifications and good teaching experience) OF THE PHYSICS DEPARTMENT—The Clerk to the Governing Body, Battersea Polytechnic, London, S.W.11.

INSTRUCTOR or ASSISTANT PROFESSOR IN VERTEBRATE PHYSIOLOGY—Prof. I. McT. Cowan, Department of Zoology, University of British Columbia, Vancouver 8, B.C., Canada.

JUNIOR BACTERIOLOGIST (with a degree or equivalent qualification), for research in the field of fruit and vegetable preservation—The Director, Research Station, Fruit and Vegetable Canning and Quick Freezing Research Association, Chipping Campden, Glos.

LECTURER IN THE DEPARTMENT OF MATHEMATICS—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

LECTURER or ASSISTANT LECTURER (with a good honours degree or equivalent, and experience in a branch of the cereal or baking industry) IN THE DEPARTMENT OF FOOD SCIENCE—The Secretary, Royal College of Science and Technology, Glasgow.

LECTURER (with a degree or Corporate Member of a professional body) TO TEACH ELECTRONICS to Higher National Certificate Diploma and Degree students—The Registrar, Hatfield Technical College, Roe Green, Hatfield, Herts.

LECTURER (with a degree or equivalent professional qualifications, together with some teaching and industrial experience) IN ELECTRICAL ENGINEERING at the Norwich City College and Art School, Ipswich Road, Norwich—The Director of Education, City Hall, Norwich.

LECTURER (with a good physics degree, or Corporate Member of the Institute of Physics, and preferably teaching experience) IN PHYSICS—The Principal, North Staffordshire Technical College, Stoke-on-Trent, Staffs.

LECTURER (with an honours degree and preferably some experience in microbiology or physiology) IN BOTANY; a LECTURER (with an honours degree and preferably some experience in microbiology or physiology) IN ZOOLOGY; and a LECTURER (with an honours degree and preferably a knowledge of nuclear physics or geology) IN PHYSICS—The Principal, Paisley Technical College (Central Institution), George Street, Paisley, Renfrewshire.

MATHEMATICS MASTER (good honours graduate)—The Headmaster, King Edward VI School, Retford.

POST-DOCTORAL RESEARCH FELLOW IN UPPER ATMOSPHERIC PHYSICS—Dr. A. Vallance Jones, Department of Physics, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

PROFESSOR OF ANATOMY OF DOMESTICATED ANIMALS, HISTOLOGY AND EMBRYOLOGY; and a PROFESSOR OF GENERAL BACTERIOLOGY, GENERAL PATHOLOGY AND GENERAL PARASITOLOGY—The Dean, College of Veterinary Medicine, Ministry of Agriculture, Baghdad, Iraq.

QUALIFIED TECHNICIAN (male or female) FOR PHARMACOLOGY—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

RESEARCH ASSISTANT (graduate in medicine or physiology) IN THE DEPARTMENT OF EXPERIMENTAL PATHOLOGY, to join a team investigating permeability factors and their inhibitors occurring in mammalian species—The Director, Lister Institute of Preventive Medicine, Chelsea Bridge Road, London, S.W.1.

RESEARCH ASSISTANT (with a qualification in some branch of chemistry, and preferably experience in analytical or physical methods) IN CHEMISTRY, for research on serum lipo-proteins—Dr. W. G. Dangerfield, Pathology Department, North Middlesex Hospital, London, N.18.

RESEARCH ASSISTANTS (honours graduates or students entering for final honours (special) degree examinations in June) IN (*a*) CHEMISTRY and (*b*) PHYSICS—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18.

SENIOR LECTURER IN ZOOLOGY; and an ASSISTANT LECTURER (Grade B) IN ZOOLOGY—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

SENIOR TECHNOLOGIST (with wide histological experience, and preferably photographic experience), to take charge of a histology department—The Secretary, Central Laboratories, Imperial Cancer Research Fund, Burtonhole Lane, London, N.W.7.

REPORTS and other PUBLICATIONS

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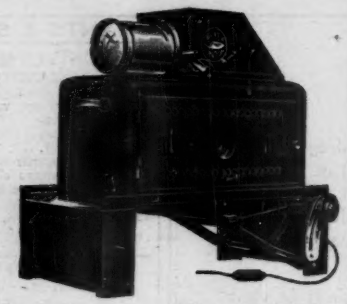

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